POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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POWER COMES

Some five thousand years ago the Great Pyramid of Cheops was built at Giza. How many slaves labored on it, how many years went by before it was completed can only be guessed at today; the time, it is said, was measured not in years but in centuries. To this day, however, the Great Pyramid remains the largest structure man ever built. ¶ But it will not be for long. In the State of Washington, on the Columbia River, Grand Coulee Dam is under construction and when that is completed the Great Pyramid of Cheops will take second place among man's greatest structures. For the eleven million cubic yards of concrete entering into its construction will exceed in bulk the mass of the Great Pyramid of Egypt. ¶ The construction of Grand Coulee Dam, however, will not be measured in centuries. Less than a decade will be needed, for Grand Coulee is being built not so much by man as by power. The several thousand men engaged upon the project must be regarded, not as laborers, but as directors of power. In that fact lies the great difference between our age, the power age, and the age of the Pharaohs—in our knowledge of the production and distribution and use of mechanical and electrical power. ¶ By virtue of power the job that formerly required hours and days, today, is performed in a matter of minutes. A single power-operated shovel handles as much material in a single minute as formerly was handled by a person, manually, in an entire month. A handful of men in a power station turn out power equivalent to the work of five million men. An automatic station turning out hundreds of thousands of kilowatt hours is connected with points of human control by nothing more tangible than a telephone wire. Human beings, today, are necessary only as directors, not as toilers. ¶ Power has come of age. It has become a vital part of our existence. This is reflected, this year, more than ever before, in the unprecedented increase in the use of electric power. All through the year the load curve surged upward, far beyond all previous heights; for the first time in history the output exceeded ten billion kilowatt hours per month. ¶ The full significance of this is far greater than most people, even those in the power industry, realize. It is far more than a mere aspect of recovery from the economic depression; it represents a demand for power far above that of even the best boom year. It is a manifestation of an increase in the "energy level" of the nation—of the world; of a developing consciousness of power; of an irresistible dynamic force which is rapidly transforming not only the face of the earth but also our ways of thought—our philosophies of life. ¶ The technological facts of power production and its distribution, electrically, are molding a new age and a new pattern of living. They involve a readjustment not only of a highly organized industrial organization but our distributive system of individual enterprise as well. We no longer think in terms used by our grandfathers. The key to these changes lies in the fact that power in the future will be measured less by its scarcity value and more as a relatively inexpensive or free goods. ¶ All these things are woven into the pattern of pictures on this page—pictures selected at random from the year's records. Varied as they are, all are part of the picture as a whole, all are connected and interrelated by the common element, POWER—the common denominator of all terms of modern life.

For description of photographs, see page 75.

S OF AGE

POWER DEMANDS SHATTER ALL

Increasing industrial output, greater residential construction, expansion of service in rural districts, reduction in unemployment, lowering of rates, reduction of appliance costs, easy payment credit terms, all aid in making 1936 the record breaking year for electric power production.

WITH A START in January well above all previous years, the power demands placed upon public utility electric plants maintained an increasing lead throughout the entire year 1936. Many factors have contributed to this most desirable result but the chief cause, it can hardly be questioned, was the general rise in industrial activity which has swept through the country as the aftermath of the depression. This impetus has expressed itself, among other ways, in a desire of industry to take advantage of all opportunities offered by the modern use of electricity in the production of products, and of householders to increase the comforts of their homes by the use of every convenience they could possibly afford.

These waves of power applications have spread in every conceivable direction and at a rate that has outstripped all other lines of industry that are recognized as of major importance to the welfare of the country. So rapidly has this rejuvenation of the power industry taken place that some are wondering if it is not just a temporary boom that will end suddenly when industry in general gets back to the point where the needs of the country are supplied at a normal competitive rate. A study of trends in all lines of industry, however, and the ever increasing applications of electricity would indicate that the saturation point in the use of electric power is nowhere in sight and that the demand of the public will grow, as it has in the past, for some generations to come.

Application of Electricity Attractive

It so happened that in the year 1936 people in factories, homes and on farms took a look at the great progress that had been made in electrical equipment, appliances and distribution systems during the past decade and at the first opportunity decided to make all possible use of this power agency to lighten not only their physical but their economic burdens and to enjoy comforts which they have long denied themselves.

The evidence of this demand is seen in every available index as will be shown in this analysis, not alone in a few favored industrial fields, but, almost without exception, the important basic industries that touch the power field, either as generators of power, users of power or suppliers of power equipment, have shown an unusual advance during the past year. All this activity seems to have had a cumulative effect upon the electric power consumption, resulting in widespread activity in the construction of power plants along the most modern designs.

In the utility field, the power company has no choice but to supply customers' requests for power service or

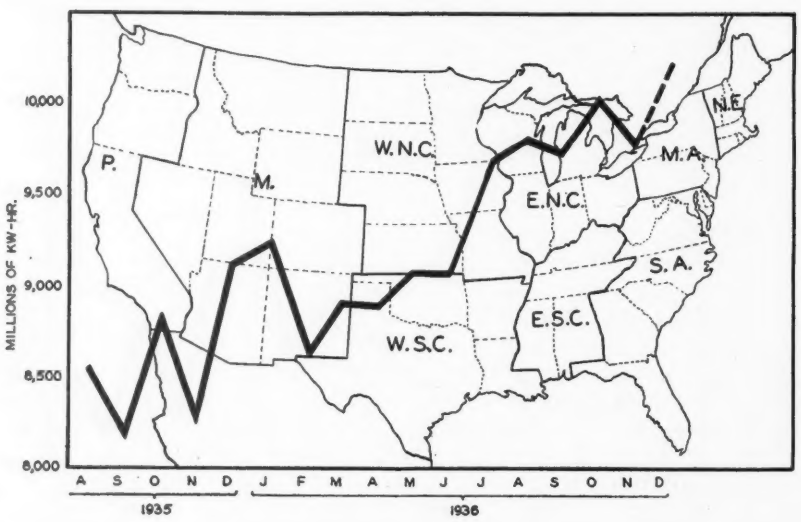

Fig. 1. Monthly production of electricity for public use in the United States

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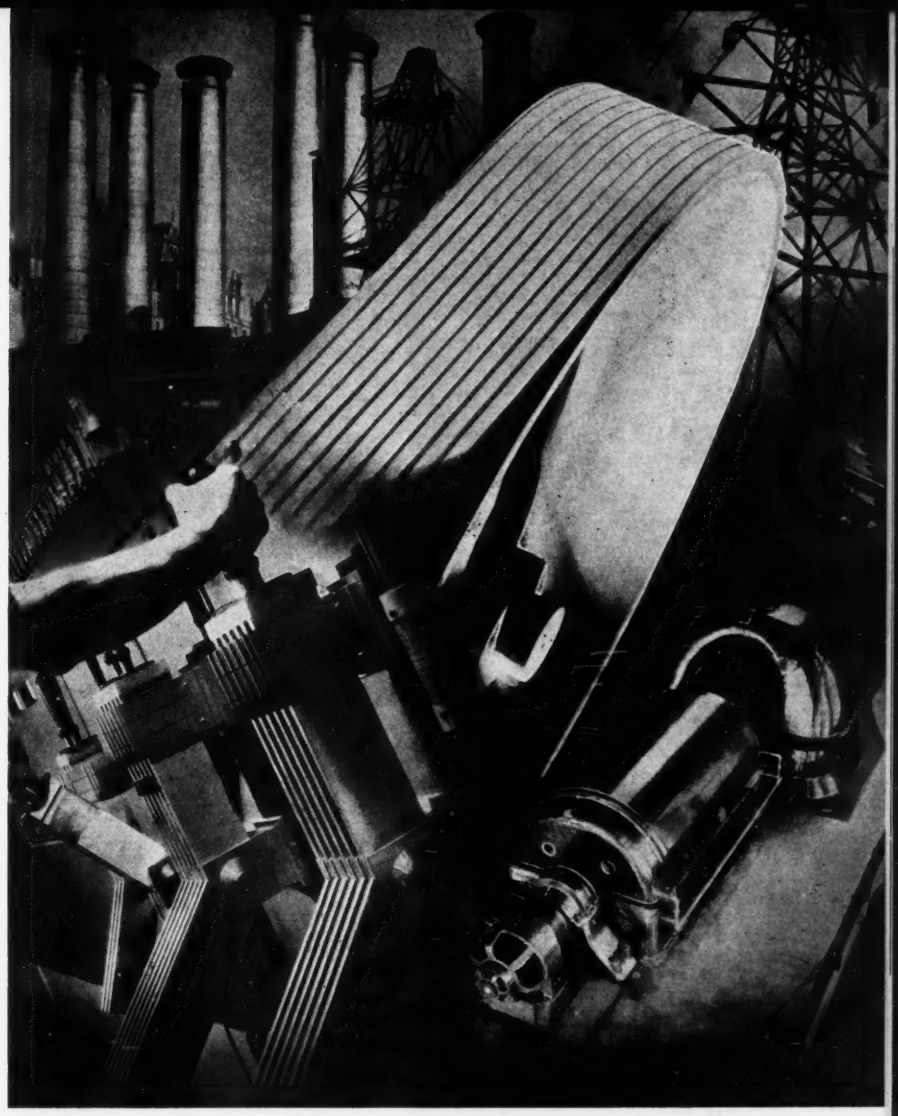


lose its franchise. It is safe to assume, then, that the demands upon power companies have been met and are represented by the load curve of electric power production. This curve, shows normal variation characteristic of the season or month, with some deviation, but at a greater increase than has taken place in previous years even prior to the depression, this rate ranging, for the entire country, from 11 to nearly 20 per cent over similar months of the previous year.

Seasonal variations are recognized by a peak in December and a valley in June, following in general the need for lighting. Industrial loads usually pick up in the fall and continue fairly evenly until the spring activities are over. Irregularities in this general curve may be expected during the short month of February and in those months containing national holidays, such as Memorial Day, Independence Day, Labor Day and Thanksgiving Day. Christmas and New Year's Day are generally observed in industries but on these occasions the additional lighting loads in residences and stores offset to a considerable extent the loss of one day's industrial load. In February the dip in the curve is accentuated, not only on account of the short month, but also because of the observance in many industries of Lincoln's and Washington's birthdays. Variations from these general characteristics would indicate such conditions as changes in industrial power using customs, in residential use of electricity, in territories served such as new lines in rural districts, in weather conditions affecting the country generally, and fluctuations in general business.

A somewhat modified picture of the power production is obtained from Fig. 12 which is a comparison of the load during the past year with the average output during the years 1928 to 1930 considered as equal to 100. This curve, the result of monthly plotting, is considerably smoother than Fig. 1, but still shows seasonal and monthly dips. It is helpful in comparing yearly and seasonal variations but not quite so direct in comparing trends as is Fig. 13 which is plotted each month, using the output of the last 12 months for the vertical scale. Thus it will be seen that a curve that bends upward indicates a rising trend, a straight curve a static trend and a downward curve a falling trend.

Breaking down the monthly load curve into that carried in the various sections of the country, an idea of the effects of different happenings can readily be distinguished. For example, the New England curve has an unusually sharp dip in March readily accounted for by the disastrous floods experienced in that section. Curves for the Middle Atlantic and the East North Central sections show some similarity except for March, April and May. The flood conditions in the Middle Atlantic section readily account for this as they reduced the power output in that section and, for a period of time, power was supplied over high-tension lines from Ohio and other parts of the East North Central section.

In a general way the curves for the other sections of the country follow the curve for the entire country except in the South Atlantic section where decided peaks occurred in January and March, plainly showing industrial conditions strikingly different from those of other sections of the country.

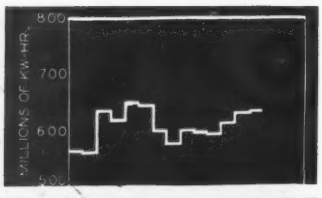


Fig. 2a. Power output curve for New England

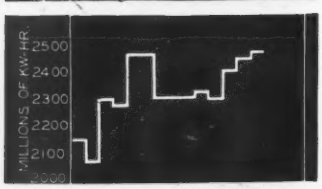


Fig. 2b. Power output curve for Middle Atlantic

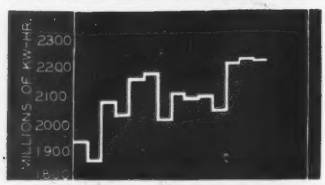


Fig. 2c. Power output curve for E. No. Central

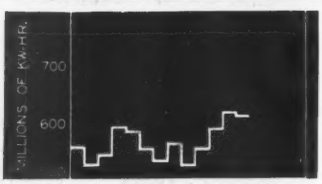


Fig. 2d. Power output curve for W. No. Central

Fig. 2e. Power output curve for South Atlantic

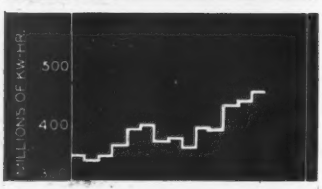


Fig. 2f. Power output curve for E. So. Central

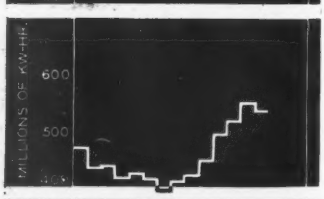


Fig. 2g. Power output curve for W. So. Central

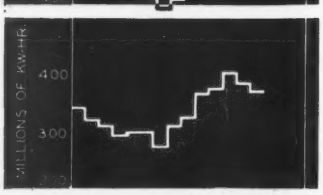


Fig. 2h. Power output curve for Mountain States

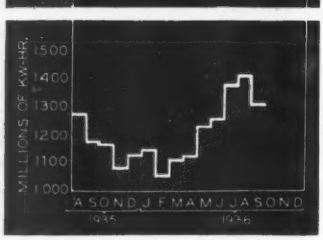


Fig. 2i. Power output curve for Pacific States

Load curves for 1936, in nearly all sections of the country, indicate that the low point of the year occurred in February with a hovering pick-up through the spring months and a decided rise between June and July which is only partly explained by the rise in general business conditions, since the load curve rises more rapidly than the business curve and such a decided rise has not been previously experienced at that season of year. Some utility executives credit the increased use of refrigerators and air cooling systems with a substantial share of the increased load and are hopeful that these new summer loads will assist in maintaining an even load throughout the year.

Changing Characteristics of Load Curve

As the country works itself out of the depression, the characteristics of the load curve are bound to change, industries varying their purchased power requirements, residents using electricity in different ways, agriculture looking more and more to purchased power to help the farm family with its work. To aid in a study of this entire problem, the business curves of several keynote industries are presented for comparison with the power load curve. From these it will be observed that the business activity curve in 14 industries shows a trend similar to the power curve with a spring dip in February and March and a rise comparable to the power curve but not so rapid, a clear indication that the utility production is advancing more rapidly than the average of other important industries.

Freight car loadings of merchandise experienced the characteristic spring recession with only a gradual rise during the remainder of the year. Auto production, one of the first industries to advance from the low point of the depression, is well back to the 1923-25 level and shows some improvement over 1935. It unquestionably has stimulated production in a number of other industries. Malleable iron castings, for example, are produced with almost identically located peaks and dips. Steel castings, however, although more than doubled in monthly output during the year, have done so along a curve that is almost a straight line. As might be expected, industrial production in factories follows almost identically the business activity in industries and is also strangely similar to the curve of electrical production except for the steeper rise of the electric curve.

Load Building Influences

Increased activity in nearly all lines of industry is undoubtedly the reason the electrical production has been rising so consistently; there are, however, changes taking place in equipment used in industry, in the appliances used in residences throughout the country and in the shop and market places whose influences on the utility load are resulting in an ever increasing demand. Consideration of these changes is highly important, for it is largely upon them that the electric utility load has been built up out of the depression at a rate much faster than any other major industry on record.

One of the most important indices of industry which points to a growing demand for electric services is the residential construction contracts awarded. From almost nothing during the years of the depression, the contracts awarded reached nearly a constant at 25 per cent of the 1923-25 average during the latter months of 1935, but beginning with March 1936 the number took a definite and steady uptrend to nearly 50 per cent of the 1923-25 average. The completion of these contracts is bound to add substantially to the electric load and in a proportion greater than would have been the case 10 yr. ago because of the broader use of electric appliances in the home. The full effect of these new residences has not as yet been experienced, since many of these homes have not yet been occupied.

Another important index in this study of electrical power needs is the orders for electrical goods such as electrical motors, storage batteries, domestic appliances, industrial equipment, and other electrical apparatus and supplies as reported by 78 leading manufacturers. The value of these goods, a great share of which will draw current from the utility lines, increased from $139,012,116 in the last quarter of 1935 to over 153 million dollars in the first quarter of 1936, to over 190 million in the second and to $189,516,083 in the third quarter. Much of this is capital goods and will draw current continuously once it is put into service.

Among the most desirable household loads, from the viewpoint of the utility, is that represented by the electric refrigerator which is showing an ever increasing popularity with the peak of monthly sales reached in May 1936 at 329,140 units. This demand for power is of course greater in hot months and is one of the influences tending to raise the summer depression in the national load curve.

Vacuum cleaners are used in nearly every electrified home. They have been and still are the sources of considerable demand for utility current. The volume of sales has reached a comparative constant depending upon replacements, new and recently electrified homes. The characteristic curve shows a spring and fall rise conforming, no doubt, with housecleaning habits of housewives.

Growing Use of Electricity in Industry

In industry and steel construction work, the electric welding load is becoming more important, not only to the utility plant but to power plants serving industrial institutions. This use of electricity is among the newer arts and its popularity is extending rapidly, as will be noted by a glance at the curve representing the sale of electric welding sets.

New steels now growing more popular on the market have been made possible largely through the use of electric furnaces. New orders for these are increasing at a rapid rate and, although the load they represent may seem inconsequential as compared with the national load, at the rate of even 3000 kw. capacity added each month, which has been considerably exceeded this past year, it would require additional generating capacity of 36,000 kw. each year to supply this new equipment in continuous operation.

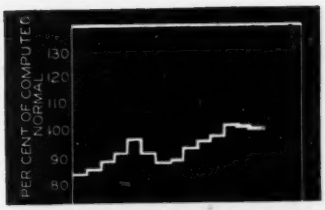


Fig. 3. Business activity in 14 principal industries combined

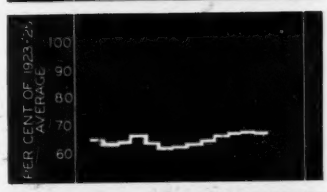


Fig. 4. Freight car loadings of merchandise, adjusted

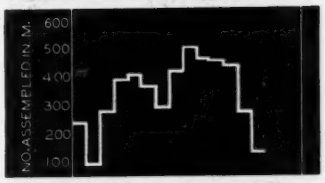


Fig. 5. Production of automobiles, total passenger cars and trucks

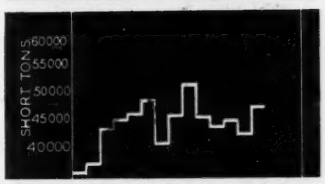


Fig. 6. Production of malleable iron castings in short tons

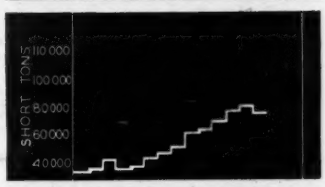


Fig. 7. Total production of steel castings in short tons

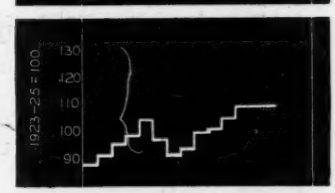


Fig. 8. Industrial production in factories, adjusted, total for 13 industries

Fig. 9. Residential construction contracts awarded, adjusted

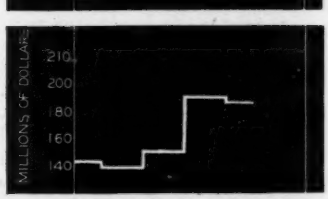


Fig. 10. Value of orders for electrical goods, plotted for quarters of year

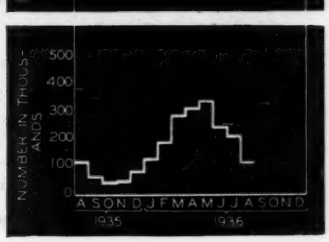


Fig. 11. Monthly variation in number of sales of household refrigerators

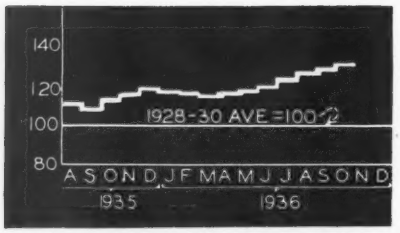


Fig. 12. Power production compared with 1928-30 average

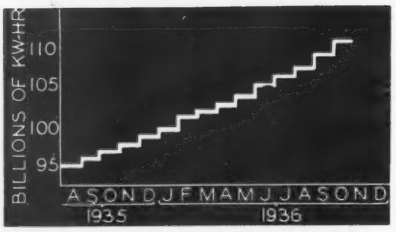


Fig. 13. Electrical output trend curve

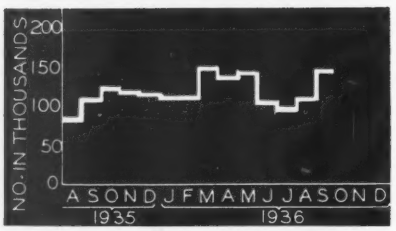


Fig. 14. Shipments of vacuum cleaners

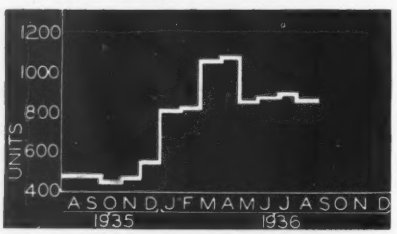


Fig. 15. Orders for electric welding sets

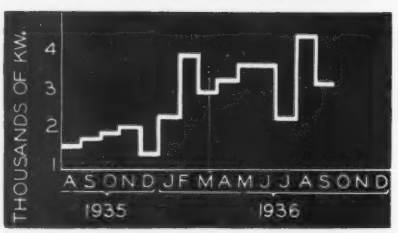


Fig. 16. Orders for electric furnaces

Fuel-burning equipment in households is rapidly becoming mechanized with motors under thermostatic control operating oil burners and stokers, and with additional motors to give forced circulation of air or hot water, according to the system used. Proof that these loads are growing requires only a glance at the curve of new orders for oil burners and domestic size stokers.

Associated with the heating system is air conditioning which, when complete for human comfort, involves not only heating but cooling, air filtering or washing, humidifying and air circulation. The extent of the use of electric power for this service can be judged to some extent by the fact that the cost of motors and controllers alone, for the fan systems, sold during the first nine months of 1936, amounted to $622,215. The summer load for cooling systems is attractive to utility companies as a means of evening out the yearly load curve.

Electrification of farms under the stimulus of the Rural Electrification Administration has made remarkable progress during the past year but as only a part of the proposed rural lines are in service, the effect on the load curve is not nearly what may be expected within the next year or two. Utility companies are now serving nearly 900,000 farms of which approximately 100,000 have been added during the past year. Joseph S. Webb of the Philadelphia Electric Co. estimates that the farmers in the territory served by his company alone are still using 7540 gasoline engines which could all be replaced by motors; that there are 14,713 farms in the territory with only 7140 farm houses reported as having running water, of which 4890 have bathrooms; that those farmers have 3410 silos which, if all were filled by using electric power, would return $10,230 each season. Such conditions indicate a wide field to be covered in water systems, water heaters, washers, irons and allied equipment which is being opened up by rural lines served by power companies.

Thus the year 1936 has been remarkable for the rapid growth in the use of electricity. The load curve is substantially above that for 1935, and far above the predepression peak of 1929; and the trend as indicated in Fig. 13 is increasingly upward.

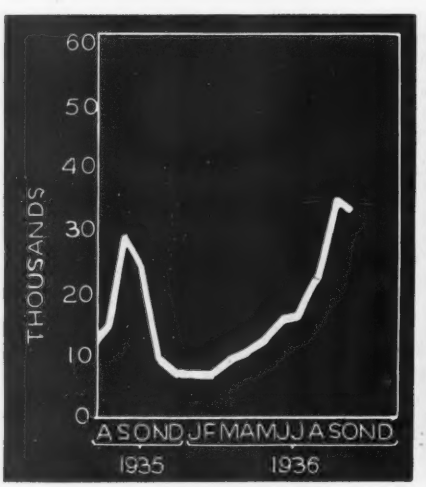


Fig. 17. Orders for oil burners

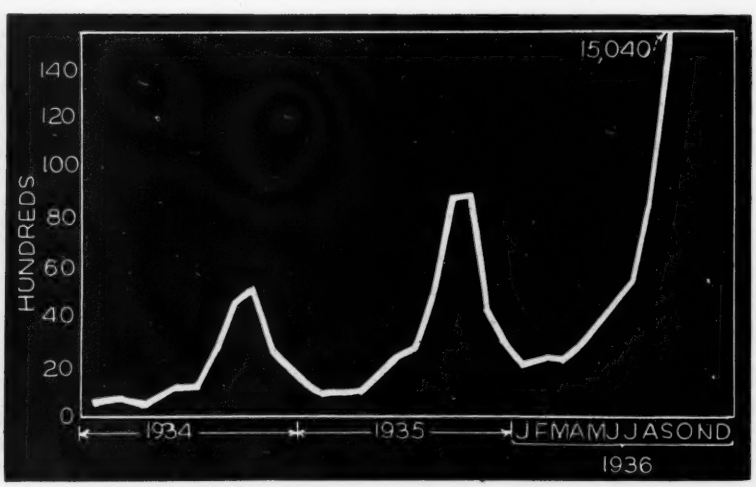


Fig. 18. Sales of domestic size stokers

PLANT CONSTRUCTION

Continues to Meet Power Demand

Utility companies have worked with determination to meet all power demands, interconnection has been helpful; plant construction along new lines is proceeding rapidly; equipment sales have advanced at unusual rate; obsolete equipment a burden to industry.

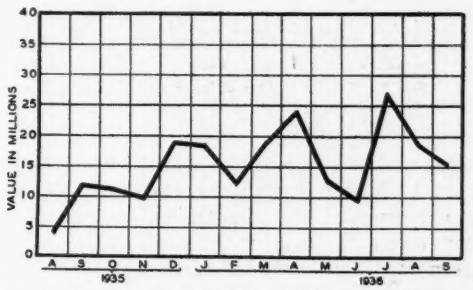


Fig. 1. Public utility construction contracts awarded in 37 states

PHENOMENAL as has been the increase in power production, as yet no shortage of power has been experienced due to lack of generating capacity, even in spite of decreasing capacity in public utility plants since 1932 when the total average for the year was 33,554,600 kw., reaching as low as 33,162,200 kw. in September, 1935, since which time added construction has brought the capacity up to 33,891,400 kw. in October of 1936. This is divided into steam power 23,938,500, water power 9,318,100 and internal combustion power 634,800 kw. With a definite trend upward in power consumption, construction of utility plants has been progressing at an unusual rate during 1936 with every indication that the industry will supply ample capacity for all need, even if the present rate of increase in power demands is continued indefinitely.

Interconnection Plays Part

That the power plants of the country have been able to supply the power needs without public inconvenience is due in no small measure to the interconnected power systems which have enabled overloaded plants to draw power from plants capable of taking on higher loads. Engineering developments of the past decade have made it possible to operate equipment at a higher rating and for longer periods of time than formerly without the necessity for shutdowns. This has also been a factor contributing to the excellent service rendered by power plants.

For several years, engineering organizations had been at work on plans for plant construction, both for new plants and for plant extensions, waiting for a defi-

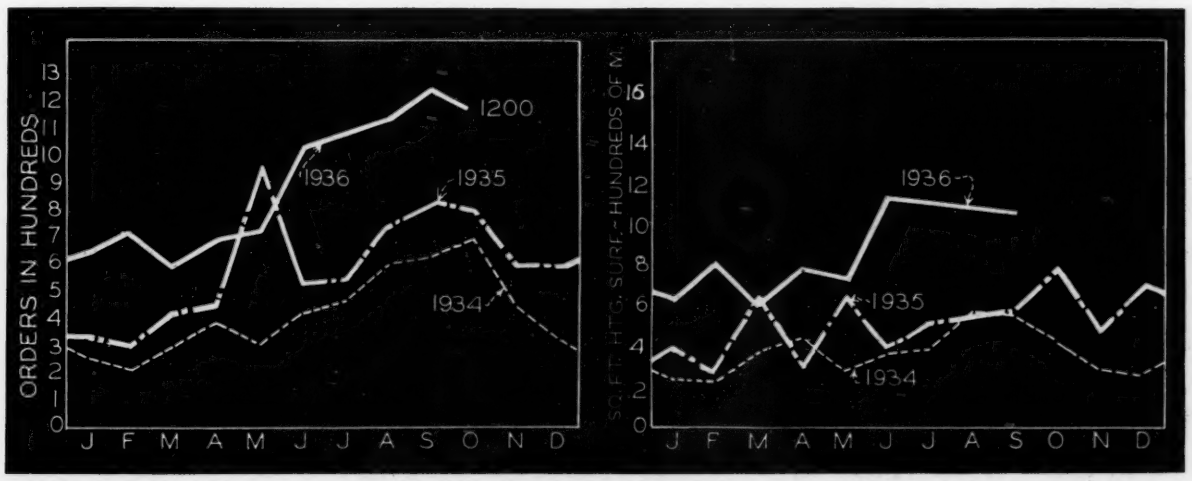


Fig. 2. New orders for steel boilers presented in curve form

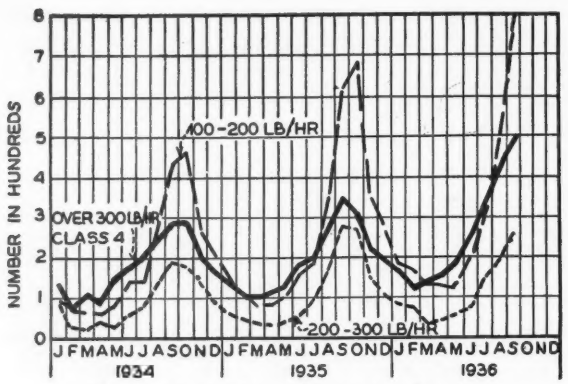

NUMBER IN HUNDREDS
100-200 LB/HR
OVER 300 LB/HR
CLASS 4
200-300 LB/HR
J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1934
1935
1936

Fig. 3. Sale of stokers of large and medium size

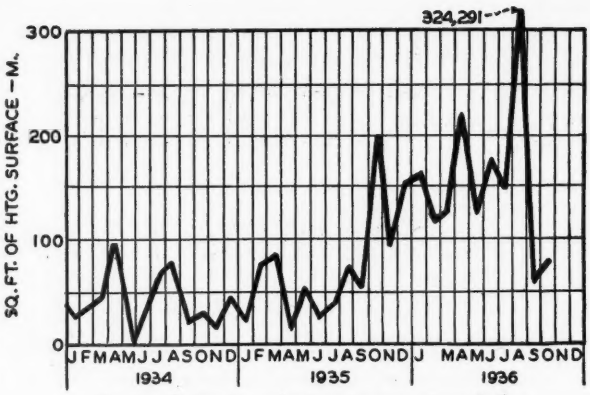


Fig. 4. Orders for pulverizers to serve steam boilers

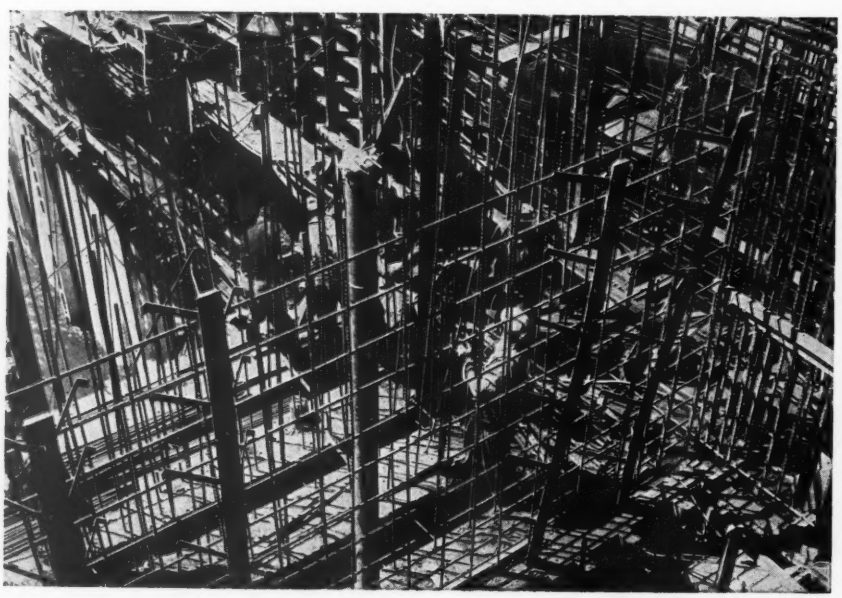
nite need for additional power capacity before beginning the construction work. This need began to present itself in 1935 and during the early months of 1936 actual construction work began in those sections of the country where the need was most pressing. The construction contracts awarded have continued throughout the year, somewhat irregularly in value but consistently above the previous year, making the advancement amount to many millions of dollars, as may be noted by reference to the accompanying curve.

Top Plants Offer Opportunities

Among the utilities, the choice of plant design for plant extension seems to favor the superposed arrangement, although a number of other designs have been built, as will be discussed in detail in another section of this issue. It has been noted that the superposed addition is attractive in plants requiring increased capacity, where the existing unit of modern construction, was not more than about 10 yr. old. For entirely new plants, some engineering concerns have worked up what might be called standard designs in the medium-pressure brackets which can readily be adapted to local conditions, and in this way much time has been saved in getting construction started after authorization to build has been secured.

In addition to the construction carried on by private capital, many cities have secured Federal Government aid either in building entirely new plants or in improving existing power-supply systems. This practice is observed to be particularly popular in the small cities and villages of the agricultural sections of the country. Here Diesel-engine units are a common choice.

Some hydroelectric power plants have been put into operation during 1936, the increase in capacity for public service amounting to about 60,000 kw. for the year. Although a number of extremely large hydroelectric projects have been under construction for some time by the United States Government, these are not yet serving the public, but some are scheduled for completion in 1937. In addition several power districts operating with Federal aid have hydroelectric plants about ready for service. More information is given on these in another article of this issue and they will not be discussed further here other than to say that with plans now under way the electric generating capacity, which will be available for public use, will meet all anticipated demands for power as the need arises.



THEY KNOW WHAT THEY'RE DOING—Working in a maze of reinforcing steel erecting the Bonneville Dam, now under construction on the Columbia River with an initial allocation of $32,440,700 from the Public Works Administration.

Industries Lag in Power Plant Construction

Industrial institutions have been slower in bringing plant capacities up to requirements than have the utility plants to which the above remarks refer directly. In many cases the real situation seems to have been overlooked until power plant services have failed to function properly. This general condition has resulted in a rush of orders for all kinds of power plant equipment which has been welcome to the manufacturers, nevertheless, disconcerting as it found many of them unprepared for such a rapid upturn in business. This situation, however, is being cleared up as managers, studying the trends of industrial and business conditions, realize that the needs of the country, long held in restraint, must be met and are rebuilding their organizations and modernizing their manufacturing facilities to care for the estimated normal demands upon their plants.

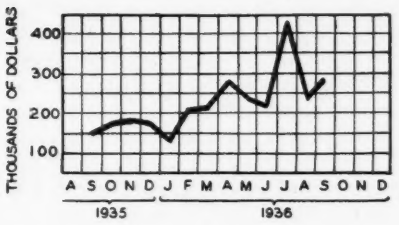


Fig. 5. Value of orders for power switching equipment

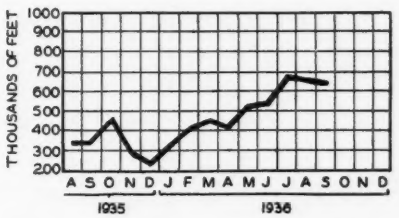


Fig. 6. Electric power cable shipments from factories

Boiler Orders Mount

No better index to volume of power plant construction can be had than the number of steel boilers sold and the square feet of heating surface they represent. This data, secured from the U. S. Bureau of Census, is presented in chart form and is enlightening as it compares the activity of the last three years and leaves no doubt as to the direction in which steam-generating capacity is going. Without question, a large share of the boilers purchased are used in modernization work where up-to-date higher capacity equipment is used to replace obsolete units. A point to be observed, however, is that the steam generating capacity is advancing at a higher rate than the power production curve, which is essential if capacity is to keep ahead of needs and at the same time retirement of old boilers is properly made.

Along with the sale of boilers goes such accessory equipment as stokers and pulverizers. The sale of this equipment, however, is taking place at a rate greater than that necessary to care for all the new boilers being sold, which is unmistakable evidence that a substantial share of this fuel-burning equipment is being used to modernize old steam-generating equipment.

Power switching equipment sales and power cable shipments are both indicators of trends in the development of the country's power plants and electric supply system. The steep upward trend of both those curves is further evidence that all power plant equipment sales fall in line with public utility construction contract awards which in turn are forced to keep ahead of the demand of the public for electrical power.

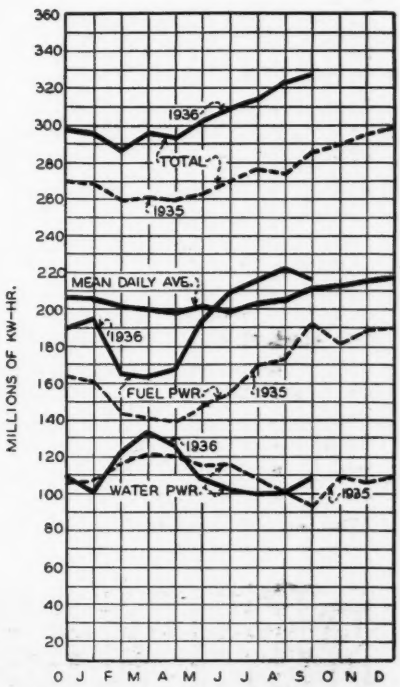


Fig. 7. Average daily production of electricity for public utility plants

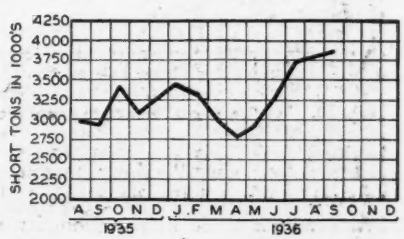


Fig. 8. Bituminous coal consumption in electric power plants

Sources of Power

In the United States, power produced in hydroelectric public utility plants ranges from 30 to 40 per cent of the total output of the country, the variation being due principally to the water available as it is customary to operate these plants as base load stations wherever possible, allowing the swings to be cared for by steam plants in the system, thus taking advantage of all possible fuel savings. From reports available at the time of this writing, the hydroelectric power produced in 1936 will average about 37 per cent of the total pro-

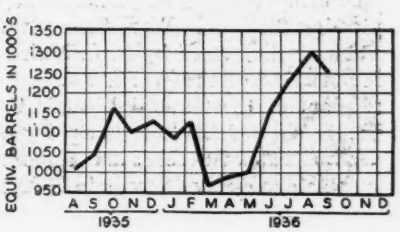


Fig. 9. Gas and fuel oil consumption in electric power plants

duction so that fuel consumption is, proportionately to the load, slightly lower than for average conditions. How the power produced by the two sources has varied throughout the year may be observed on the chart of average daily production of electricity by public utility plants and for further study of fuel variations, the curves of bituminous coal consumption and gas and fuel oil consumption are presented as they are an indication of changing conditions that must be met as the load demand and rainfall vary.

Increase in Economy of Production

From the data presented here, it is clearly evident that not only the utilities but the industries that generate their own power are keenly alive to the growing

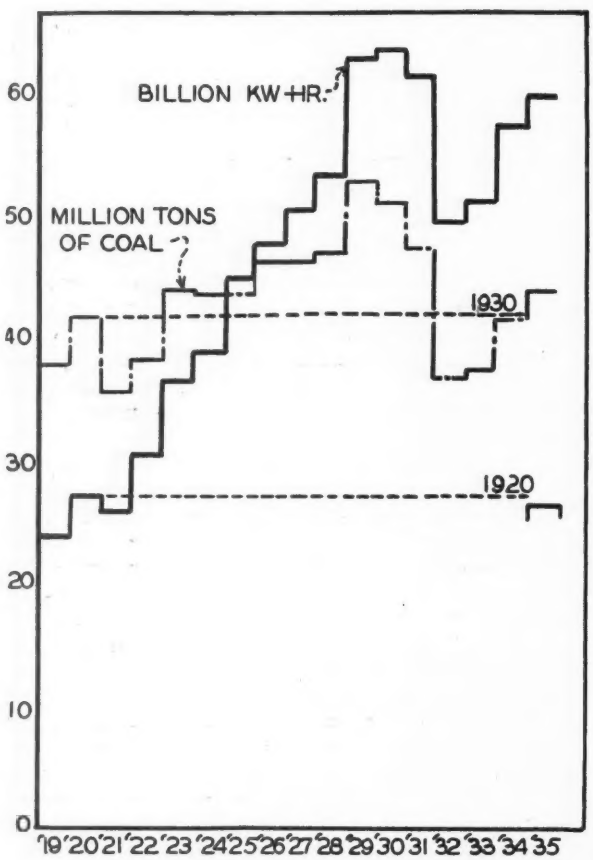


Fig. 10. Relation of coal burned to power production since 1919

demands for power. Many managers of industries, however, do not have an appreciation of the great advancements made in the economy of power generation during the life of plants built in the years just following the World War. This advance in the art was forcefully illustrated by R. C. Muir at the Pre-Conference meeting of the World Power Conference held at the plant of the General Electric Co. in Schenectady when he showed the two charts, Figs. 10 and 11, which indicate that with the same amount of coal used to generate our electric power in 1920 the vastly greater needs of 1930 were supplied and that even today the average steam station could reduce its coal consumption per kilowatt of output by approximately one third, if modernized comparable to the best stations. The best record so far reported was set by the Port Washington plant during its first eleven months of operation when the average economy of 11,220 B.t.u. per net kw-hr. produced was accomplished; the highest economy for any one month was reached in August with a figure of 10,857 B.t.u. per net kw-hr.

Replacements Needed

Power plants of the country have, in 1936, met the needs of industry and the public but with many plants under construction and many more being planned the need for power equipment is still expanding as is unquestionably the demand for electric power. Likewise the market for replacements in power plants is large and needs are insistent. While a 10-yr. old boiler will work, even one 20 yr. old, its economy will be much lower than those of present-day design. Since

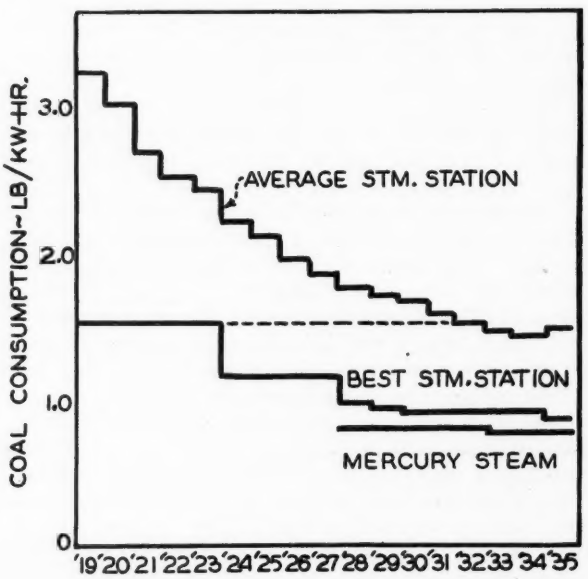


Fig. 11. Progress in heat economy of steam stations over period since 1919

half the fire-tube boilers and one quarter of the water-tube boilers in the country are 20 yr. old or more, the field for boiler replacements is tremendous. For steam engines, the condition is even more urgent, as two thirds of them are beyond the 20 yr. age limit. Even in automatic stokers, usually thought of as a modern development, one fourth of those in use are of an age to be considered obsolete.

Use of such out-of-date equipment puts a heavy burden on industry as from 25 to 50 per cent of the fuel energy in plants is wasted. Some four billion dollars would have to be expended to make the desirable replacements and while uncertainty as to the future of industry may delay some of the needed work, there is a pronounced tendency to go ahead as business improves and many plants are planning for remodeling and modernization.

KEEPING STEP with the Power Load

No let-up in record rush to add new capacity to utility and industrial systems. Top units predominate but moderate pressure-high temperature plants gain in more recent announcements.

WHEN DEALING with such a specific matter as new plants, in a year which sets new highs for activity, it would seem that definite conclusions could be reached and that trends would be easily discernible. As a matter of fact, future trends are screened by and depend to a large extent upon the performance of top plants now under construction. All that can be said is that reheat has been abandoned and the trend is toward higher temperatures and lower pressures.

At present top plants predominate, the reasons for this being discussed in later issues. One of the common reasons, however, is a need for immediate additional low cost capacity. Local conditions have, of course, influenced all of the designs as the pressure and temperature limitations of existing equipment and available space of buildings cannot be escaped. In some cases condensing water was a factor. Thus at Millers Ford and Elm Street limited condensing water made a top plant the only possible method of expansion.

Much the same condition existed at Fisk Street which is unusually interesting because of the combination of frequencies supplied by this station, provisions made for future changeover as load conditions change, and the replacement of auxiliaries in the old section on which the new unit is superimposed. The auxiliaries operate on 60 cycle current but the new generator is a 1500 r.p.m., 50 cycle unit.

Utility plants actually completed this year are few, two in fact: Station No. 3 at Rochester, N. Y., and Mound Street in St. Louis, Mo. Both of these are top plants, the first step in a more comprehensive development, and in common with many top plants the turbine and boiler rooms are one without the customary curtain wall between. While this practice is not new, extending back over a decade to Toronto Station, it is not common in new plants but particularly appropriate in top plants, when it is sometimes necessary to actually put the smaller top turbine in the boiler room. At Mound Street it was done as a temporary expedient to reduce building costs for the first unit; at Fisk Street it will be done because of limited space. At Station No. 3 it was a matter of convenience and simplicity, omission of the condenser and cleanliness due to pulverized coal both being contributing factors.

Omission of the curtain wall is, of course, one step in cutting building costs. At the new Provo, Utah, station the matter was carried a step farther and a semi-outdoor construction resorted to. Several outdoor hydro plants have been built and a few years ago serious consideration was given to steam plants of this kind although the Schenectady mercury plant is the only one to get beyond the paper stage. It seemed to be the general opinion that the savings on a kilowatt basis was small and could be nearly equalled by careful building design. At Provo, however, preliminary estimates indicated a saving of between $100,000 and $150,000 or between $6 and $10 per kw. In the municipal plant field Lakeside station in Springfield ranks high from both an engineering and architectural standpoint as well as being the center of an important civic recreational area.

Waterside is of interest because it represents the modernization of one of the oldest central stations in the country and because of the unique turbine construction, a small turbine on the end of the main shaft having its own governor and being used only for supplying extraction steam for feedwater heating purposes. Logan is of interest because it was the first large high temperature installation to be announced and because of the large double boiler designed for producing 1,000,000 lb. per hr. of 1425 lb., 925 deg. F. steam.

Windsor station on the other hand, is notable for the 60,000 kw., 3600 r.p.m. turbines driving hydrogen cooled generators. These are the largest high speed turbines to date for back pressure operation. Montville with a 25,000 kw., 3600 r.p.m. unit now holds the record for 3600 r.p.m. condensing units. By going to two cylinder construction this limit can be boosted to about 40,000 kw. for condensing operation but 60,000 kw. is close to the ultimate limit for back pressure operation and will probably never be exceeded by a wide margin.

State Line proceeding with plans started several years ago is unique in having the only reheat installation under construction at present, plans having gone too far to change in accordance with the present high temperature trends. The turbine is a 150,000 kw. unit and will probably be the largest unit put into service for some time to come. The 75,000 kw. unit for Cahokia is the largest unit to be ordered in 1936. Boiler pressure and temperature for this extension will be 330 lb., 740 deg. F. to conform to the original sections, the possible improvement due to higher pressure and temperature not being considered sufficiently great to warrant the change. The same may be said

Partial list of utility, municipal and industrial steam plants, complete, under construction and announced during the year 1936.

STATION	LOCATION	COMPANY	DATE OF COMPLETION	BOILERS						TURBO-GENERATORS						
				NO	TYPE	LB./HR.	TYPE	PRESS.	TEMP.	NO	KW.	R.P.M.	THROTTLE PRESS.	THROTTLE TEMP.	EXHAUST PRESS.	EXHAUST TEMP.
MUNICIPAL PLANTS AND CENTRAL STATIONS																
Ottawa Street (7)	Lansing, Mich.			2		250,000	Pul. Coal	925	900	1	25,000				1"	
										1	4,000	3600	825	900	200	
Waterside	New York City	New York Edison Co.	May '37	2	St. Tube	500,000	Pul. Coal	1400	900	1	2,500				15	
Goos	Goos, Mich.	Upper Michigan Power & Light Co.	July '36		Bent Tube	100,000	Pul. Coal	448	680	1	50,000	3600	1800	900	200	500
Steel Point (8)	Bridgeport, Conn.	The United Illuminating Co.	Dec. '36	2	Bent Tube	100,000	Pul. Coal	650	845	1	1,875	3600	425	610	175	460
Fort Collins (9)	Fort Collins, Colo.	Municipality	May '36	2	Bent Tube	25,000	Stoker	430	750	1	5,000	3600	645	845	217	600
Quindaro No.2 (9)	Kansas City, Kans.	Municipality	Late '37	1	Bent Tube	150,000	Pul. Coal	450	750	2	1,500	3600	400	700	1"	
Springdale (9) (10)	Springdale, Pa.	West Penn Power Co.	Nov. '37	3	St. Tube	500,000	Pul. Coal	1270	935	1	30,000	7800	400	725	1.5"	
Riverville (9) (10)	Fairmount, W. Va.	Monongahela West Penn Public Service Co.	Nov. '37	2	St. Tube	315,000	Pul. Coal	1240	915	1	20,000	3600	1235	925	340	622
Windsor	Beech Bottom, W. Va.	Ohio Power Co. & West Penn Power Co.				Not Scheduled				1	25,000	3600	1200	900	260	556
Celanese (10)	Cumberland, Md.	Celanese Corp.	June '37	1		150,000		450	750	2	60,000	3600	1250	925	235	545
Cedar Rapids	Cedar Rapids, Iowa	The Potomac Edison Co.								1	10,000	3600	400	700	140*	510
Station No.3 (11)	Rochester, N. Y.	Iowa Electric Light & Power Co.	Early '37	1	St. Tube	300,000	Stoker	750	765						60	372
Omaha (11)	Omaha, Nebr.	Rochester Gas & Electric Corp.	Jan. '36	1	Bent Tube	250,000	Pul. Coal	660	755	1	5,000	3600	650	750	215	550
Provo (11)	Provo, Utah	Nebraska Power Co.	Jan. '37	1	Bent Tube	285,000	Stoker	*1225	925	1	6,000	3600	650	750	210	530
Seward (11)	Seward, Pa.	Utah Power & Light Co.	Aug. '36	1	Bent Tube	200,000	Stoker	*1410	760	1	10,000	3600	1200	900	195	515
Dresden (11)	Dresden, N. Y.	Pennsylvania Electric Co.	?	2	Bent Tube	200,000	?			1	15,000	1800	365	750	1"	
Elm Street (12)	Battle Creek, Mich.	New York State Electric & Gas Corp.	Dec. '37	2	Bent Tube	110,000	?			1	35,000		650	825	Cond.	
East Peoria (12)	Peoria, Ill.	Consumers Power Co.	June '37	1	St. Tube	360,000	Pul. Coal	900	875	1	20,000	3600	650	825	Cond.	
West End (12)	Cincinnati, Ohio	Central Illinois Light Co.	Mar. '36	1	Bent Tube	300,000	Pul. Coal	900	875	1	10,000	3600	800	850	200	580
State Line (12)	Hammond, Ind.	Cincinnati Gas & Electric Co.	June '37	1	Bent Tube	300,000	Pul. Coal	1275	910	1	25,000	3600	800	850	1"	
Fisk Street (12)	Chicago, Ill.	Chicago District Electric Generating Co.	Oct. '37	3	St. Tube	500,000	Pul. Coal	*1325	850	1	35,000	3600	1200	900	260	555
12th Street (12)	Richmond, Va.	Commonwealth Edison Co.	Oct. '37	2	St. Tube	375,000	Pul. Coal	1275	910	1	150,000	1800	1250	840	1"	
Cahokia	Monsanto, Ill.	Virginia Electric & Power Co.	Oct. '36	1	Bent Tube	450,000	Pul. Coal	925	835	1	50,000	1500	1200	900	225	535
Blue Earth	Blue Earth, Minn.	Union Electric Light & Power Co.	Nov. '37	5		260,000	Pul. Coal	350	740	1	12,500	3600			200	525
		Municipality		2	Bent Tube	20,000	Stoker	250	550	1	75,000	1800	315	725	1"	
Lakeside	Springfield, Ill.	Municipality								1	500	3600	250		5*	
Mound St. (13)	St. Louis, Mo.	Laclede Power & Light Co.	Mar. '36	1	St. Tube	110,000	Pul. Coal	410	700						Cond.	
Lynn (15)	Lynn, Mass.	Lynn Gas & Electric Co.	Aug. '36	3	St. Tube	210,000	Gas & Oil	450	750	1	10,000	3600	400	700	1"	
Holyoke (15)	Holyoke, Mass.	Holyoke Water Power Co.		1	Bent Tube	205,000	Pul. Coal	450	810	1	5,000	3600	425	750	185	480
Fort Pierce	Fort Pierce, Fla.	Municipality		1	Bent Tube	200,000	Oil	675	750	1	25,000		400	800	Cond.	
Logan	Logan, W. Va.	Appalachian Electric Power Co.		1	Bent Tube	30,000		300	750	1	17,500		650	750	Cond.	
Riverside (20)	Davenport, Iowa	United Power Manufacturing Co.		1	Bent Tube	1,000,000	Pul. Coal	1425	925	1	2,500	3600	300	750	Cond.	
Kentucky Ave.	Indianapolis, Ind.	Indianapolis Power & Light Co.		1	Bent Tube	225,000	Pul. Coal	900	825	1	40,000	3600	1865	900	200	495
Jefferson City	Jefferson City, Mo.	Missouri Power & Light Co.		2	Bent Tube	350,000	Pul. Coal	670	770	1	12,500	3600	625	750	245	620
Alexandria	Alexandria, Va.	Virginia Public Service Co.		1	Bent Tube	100,000	Gas & Oil	900	825							
Montville	Montville, Conn.	Connecticut Power & Light Co.		1	Bent Tube	60,000	Stoker	450	760							
Millers Ford (16)	Dayton, Ohio	Dayton Power & Light Co.		3	Bent Tube	100,000	Pul. Coal	725	825	1	25,000	3600	640	825	1"	
Station B (17)	San Diego, Cal.	San Diego Consolidated Gas & Elec. Co.		2	St. Tube	375,000	Pul. Coal	1375	900	1	42,000		1200	900	230	
Canal St. (18)	Louisville, Ky.	Louisville Gas & Electric Co.		2	Bent Tube	200,000	Gas & Oil	240	740	1	35,000	1800	235	750	1½"	
				2	St. Tube	300,000	Pul. Coal	475	750		25,000	1800	450	750	1½"	
INDUSTRIAL PLANTS																
Postum (18)	Battle Creek, Mich.	General Food Corp.	Sept. '36	1	Bent Tube	100,000	Pul. Coal	700	720		2,500	3600	650	720	30	321
Weirton	Weirton, W. Va.	Weirton Steel Co.	June '36	2	Bent Tube	315,000	Pul. Coal	820	820		10,000	3600	800	800	215	540
Van Brunt (4)	Horicon, Wis.	Van Brunt Mfg. Co.	July '36	2	St. Tube	10,000	Stoker	265	500		350	150	475	485	5	
Grand Rapids Stamping	Grand Rapids, Mich.	Fisher Body Div.	June '36	3	Bent Tube	135,000	Stoker	200	600				Air Compressors			
Seagram	Louisville, Ky.	Jos. E. Seagram & Sons, Inc.	Oct. '36	2	Bent Tube	69,000	Pul. Coal	400	Sat	2	750	3600	365	Sat.	90	
Monarch Mill (14)	Kalamazoo, Mich.	Allied Paper Mills	March '37	2	Bent Tube	40,000	Pul. Coal	450	670		2,000	3600	410	660	15	
Staley	Decatur, Ill.	A. E. Staley Mfg. Co.	Apr. '37	1	Bent Tube	150,000	Pul. Coal	425	650		6,000	3600	400	650	125	440
John Deere	Waterloo, Iowa	John Deere Tractor Co.	Jan. '37	1	St. Tube	60,000	Stoker	215	500		2,000	3600	215	500	3	Sat.
Union Bag	Savannah, Ga.	Union Bag & Paper Corp.	Oct. '36	3	St. Tube	33,700	Oil &	450	750						5	
Gulf Oil - #1	Port Arthur, Tex.	Gulf Oil Corp.	Dec. '36	3	Bent Tube	45,750	Waste				6,000	3600	400	750	2"	
Wilson	Albert Lea, Minn.	Wilson & Co., Inc.	April '37	2	Bent Tube	200,000	Oil & Gas	725	685						{140 - 40' Cond.	
				3	Bent Tube	53,000	Pul. Coal	300	525	2	4,000	3600	650	675	130	400
Marwell	Ashley, Pa.	Glen Alden Coal Co.	Sept. '37	4	Bent Tube	46,800	Stoker	600	635	1	1,500				{135-75-10	425-360 sat.
Great Lakes Steel (6)	Detroit, Mich.	Great Lakes Steel Co.	Jan. '37	3	Bent Tube	75,000	Fan	450	700	1	1,000	3600	280	520	135-75	425-360
River Rouge	Detroit, Mich.	Ford Motor Co.	July '36	1	Bent Tube	900,000	Gas & Oil Pul. Coal	1250	900	1	500				75-10	360 sat.
Pan American	Texas City, Tex.	Pan American Refining Co.	Jan. '37	2	Bent Tube	100,000	Oil & Gas	415	700	2	60,000	3000	400	700	2"	
Pittsburgh P.G.	Barberton, Ohio	Pittsburgh Plate Glass Co.	Fall '36	1		180,000		900	750	1	75,000					
Chevrolet Forge	Detroit, Mich.	Chevrolet Motor Co.	Fall '36	2	Bent Tube	45,000	Pul. Coal			1	110,000	1800	1215	900	250*	550
Morgan & Wright Div.	Detroit, Mich.	U. S. Rubber Co.	Fall '36	2	Bent Tube	100,000	Pul. Coal	400	725	1	15,000	3600			Cond.	
											3,000	3600	415	700	115	500
											5,000	3600			140	
											5,000	3600	400	700	160*	
															Cond.	

FOOTNOTES ON OPPOSITE PAGE

about the new 30,000 kw. unit for Quindaro No. 2 although this station is more recent and operates at 450 lb., 750 deg. F.

Water cooled stokers are the latest development in fuel burning equipment and the new 750 lb., 765 deg. F., 300,000 lb. per hr. boiler which went into the Cedar Rapids plant is fired by a stoker of this type. It offers increased utilization of the lower grade of midwestern coal at relatively high burning rates and the performance of the boiler will be a matter of interest during the coming year.

Riverside, Springdale, Omaha and West End are all excellent examples of superimposed construction, each presenting design and construction problems which cannot, however, be covered in this brief article. From the standpoint of trends in new plant design, the recently announced Steel Point, Dresden, Seward and East Peoria stations are more significant. The pressures range from 650 to 900 lb. and from 825 to 875 deg. F., which will undoubtedly be the popular central station range during the next few months.

Of course condensing operation entails a loss which utility plants can avoid only by the sale of steam or

Footnotes for table on opposite page

* Extraction Pressure
2 Boiler pressure given at Superheater outlet
4 Steam engines in this plant
6 Turbo-blowers in this plant—capacity in c.f.m.

The following names refer to the consulting engineers for various plants as indicated:

7 Burns & Roe, Inc.
8 Westcott & Mapes, Inc.
9 Burns & McDonnell Eng. Co.
10 Sanderson & Porter
11 E. M. Gilbert Eng. Co.
12 Ebasco Service, Inc.
13 Commonwealth & Southern Corp.
14 Sargent & Lundy, Inc.
15 Stone & Webster Eng. Co.
16 Management & Engineering Corp.
17 Public Utility Eng. & Service Corp.
18 Union Gas & Elec. Co.
19 Arthur Nelson & Co.
20 United L. & P. Eng. & Const. Co.

by co-operation with industrial plants. Both have been used to some extent in the past but progress has been slow. Byproduct power from district heating steam is the exception rather than the rule. In a few instances close co-operation of industrial plants and public utility systems have been possible and advantageous to both parties. As an extension of this practice, three of the new stations are of particular interest.

In Indianapolis, Ind., the sale of high pressure steam to industrial plants has over a period of several years developed into a business in itself. Much of this high pressure steam (250 lb.) is used for generating power before being used in process work, the prime movers on the customer's premises being owned either by the power company or by the customer. The steam is supplied from the Kentucky Avenue station and the new 625 lb. top unit being installed there is intended primarily to supply the 250 lb. system with steam expanded through the 12,500 top turbine.

In the east The Potomac Edison Co. and the Celanese Corp. also have a co-operative arrangement. The utility is installing a 10,000 kw. turbine which will take steam from the industrial companies' boilers and exhaust to process. Power generated will be supplemented by power from the utility system and used to take care of the power needs of the Celanese Corp. plant.

At Lansing, Mich., another interesting station has been announced. This is the rebuilding of the Ottawa Street Station by the Board of Water & Electric Light Commissioners. This is an old generating station used of recent years to supply a district heating system. Recently a large high pressure steam line was built tying this station in with a pumping station and with Moores Park Station. Rebuilding of Ottawa Street Station with high pressure extraction-condensing main units and smaller back pressure units will allow the system to take care of low and high pressure steam sales at high efficiency, add materially to the generating capacity of the system and make possible the retirement of the older pumping station boilers.

In the industrial field there are a number of unusual plants. Because of the high pressure, high temperatures, and large size, the latest addition to Ford's River Rouge Station is of major importance although this plant both in design and service is a central station. The 900,000 lb. per kw. boiler, similar to Logan, is installed in column spacing intended for a unit a quarter that size and the 115,000 kw. turbine eliminates the reheat used on the first unit by going to 900 deg. F.

Another industrial of more than usual importance is the 820 lb., 820 deg. F. Weirton Steel plant with a 10,000 kw. top unit. Using 100 per cent river water makeup the treating problem, as at Station No. 3, has been a serious one and its successful accomplishment shows how far the art has traveled in the last decade.

These high pressure industrial top plants do not, of course, have to be confined to electric power generation as the steam may well be used in compressors, turbo-blowers or other process machines with the prime mover exhausting at the former plant steam header system.

An excellent example of this practice is the Pittsburgh Plate Glass plant in which the new turbine exhausts at 140 lb. to the low pressure system in parallel with the old boilers. This plant is noticeable for two things: first, the high (for an industrial plant) boiler pressure, 900 lb., 750 deg. F. (max. 850 deg. F.) with extraction at 400 lb. believed to be the highest automatic bleeder pressure yet attempted.

Where steam quantities and electric loads are not in agreement or are of intermittent duration, a high pressure unit operating condensing may be used with extraction to supply the older steam system at pressures which will vary from 100 to 200 lb. depending largely upon the age of the old equipment. This was the arrangement used at Chevrolet-Forge one of the important industrial plants put into service last year.

Another industrial plant worthy of more than usual interest is the new Postum plant at Battle Creek. This is a single boiler, single turbine plant operating in conjunction with the utility system. Ordinarily the plant will operate non-condensing and supply process steam. Under unusual conditions, however, the unit may operate condensing or partial condensing, a small condenser being provided for that purpose. An abundance of cold water is available from the process end and the arrangement, all under automatic control, greatly increases the flexibility of the plant. Both the forced and the induced draft fans are dual driven by the same motor and turbine, and, cyclone cinder catchers are provided, so arranged that they may be cut in or out in accordance with the load so as to maintain the optimum gas velocity.

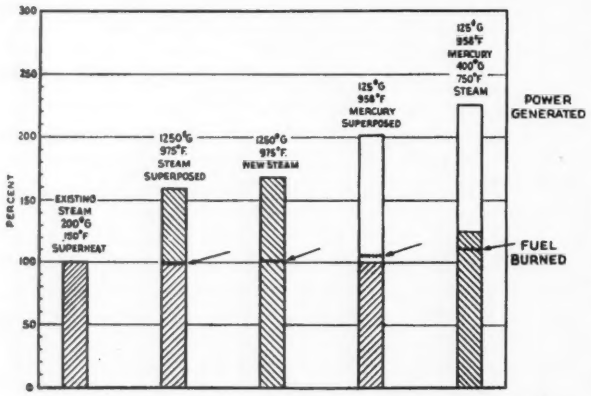
STREAM LINE TRENDS in PLANT

Superimposed plants gain the spotlight temporarily by an unexpected sprint. Reheat abandoned. New plants will favor medium pressure, high temperature range.

ECONOMIC AND POLITICAL events of the past 3 yr. cast long and deep shadows with which the technical and commercial forces of the industry were able to cope successfully, but, with which the holding company came out second best and is now clinging to the ropes hoping that the Supreme Court, as referee, will recognize the claim of foul and prevent a knock-out.

Unfortunately, general technical changes cannot be considered by themselves, because they are too closely related to economic and political events and represent a readjustment, or, change of viewpoint, rather than real technical advances. Sudden loss of industrial load in the early days of the depression led to a full appreciation of the importance of the domestic and lighting load and concerted action of the industry managed to increase the domestic revenue over the 1929 value and hold the commercial lighting and small power revenue losses to about half those of wholesale power. Up to 1933 this uphill fight was carried on solely by the industry and nothing can rob it of the credit. Since 1933 the psychological effect of power as a national issue, activities of the various government bodies, numerous rate reductions and improved business conditions have unquestionably smoothed the road considerably.

Dangers of adding this domestic load, without corresponding capacity additions to take care of the industrial load to be regained with improved business conditions, were early recognized by the industry and it is questionable if any system of considerable size in the country was without at least preliminary plans to add capacity when and where needed. Without the intervention of politics there is no question but that the orderly development of the industry would have proceeded quietly, even in spite of the Securities Act, for the public utility industry as a whole was as sound and solid as any in the country.



Modernized Power Plant Design (Courtesy, The Austin Co.)

Fig. 1. Top unit on an old plant compared with new steam and mercury plants on the basis of power generated and fuel burned with same condensing facilities

The political aspect of the Federal Trade investigation, followed by the Federal Power Commission report in 1934 charging a shortge of capacity on the utility system, definitely put the industry on the defensive. The combined effort to prove this report wrong, to show the ill effects of the Securities Act, to arouse operating companies to the dangers of the Public Utility Act and an effort to postpone action until after the election undoubtedly combined to interrupt the normal course of construction and delay the start of needed capacity to and beyond the danger point. In no other way can the rapidly mounting list of new utility construction be accounted for.

Almost without exception these are top or superimposed plants involving the rehabilitation of old stations. This trend has been foreseen for some years and has engineering justification. Yet such universal, rapid and widespread acceptance of a single idea may not be entirely without political significance. Utilities have been preaching the advantages and benefits of interconnection and long distance transmission lines for years and are now faced with the problem of fighting government projects with but two weapons, ethics and economics. These projects are either detrimental to established private interests and/or are uneconomical because of the long transmission lines involved.

Economics of long distance transmission of power have been reasonably well established within the industry for some time and the railroad still holds its own for distance of more than 50 to 100 mi. The public, however, not appreciating the gradual load drift and the small amount of actual power change in an interconnection of, say, the much publicised hookup of a few years ago from Chicago to Boston, may well be excused for inferring that transmission from Grand Coulee to Salt Lake or San Francisco may be entirely feasible. Locating all new capacity in old stations, at load centers, may help to prove to the public the fallacy of power government projects under way. Not a

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Modernized design by The Austin Co.

very effective help perhaps, but after all from an engineering standpoint the top plant and a complete new plant usually run neck and neck and, unless there are extenuating circumstances such as condensing water, limited space, etc., political considerations might well prove to be the deciding factor.

Another and probably more important political angle was the fact that top plants were, during the early part of the year, a convenient method of meeting immediate load increases without making necessary definite commitments on new plant construction until after the election. There is no question that the industry as a unit is seriously disturbed over the turn of political events. This disturbance made it advisable to hold off definite system capacity increases as long as possible in hopes conditions would ease materially.

Reelection of President Roosevelt may mean much or little as far as the industry is concerned. Certainly it will mean the continuation, and perhaps expansion, of such projects as Bonneville, Grand Coulee and the T.V.A. More important than this, however, it undoubtedly means the continued development of regional organizations under Title II of the Public Utility Act, leading to forced or voluntary cooperation of private, municipal and government facilities over wide areas, probably the first step in national planning. It is safe to say that no one knows what the future holds as the trails lead over uncharted terrain and in rough country many unexpected detours are necessary.

Meager reports from the recent T.V.A.-Utility conferences in Washington indicate a less arbitrary attitude on the part of the government forces and support of Carlisle's statement, at the World Power Conference, that there is nothing the utilities will not do to further any plan formulated on sound economics for the public good. This is also borne out by reports from the Pacific Coast utilities concerned at this time primarily over Bonneville power and disturbed over a complete Columbia River development modeled after the T.V.A.

Behind this politico-economic facade the work of the engineer has proceeded under the irresistible force of a constantly growing power load estimated to be 25 per cent in excess of the 1929 figures. This work has, however, followed old and well beaten trails but the conveyance has been streamlined and chromium plated. Superposition or topping is not new. In principle it goes back to the days when low pressure turbines were installed to take the exhaust from steam engines. Reversing the principle, Edgar and Lakeside pioneered and developed it highly. Burlington later extended the field to high temperatures.

At that time reheat and the regenerative cycle were involved, it was the era of new base load stations, and rapidly expanding systems, so superposition was temporarily shelved and the reheat station followed. The success along this line is attested by the fact that the last station of this type to be built, Port Washington, holds the world's record for heat economy, close to 10,900 B.t.u. per kw. In spite of the fact that Port Washington was not put in service until late in 1934 it is a pre-depression plant and belongs defi-

nitely to what may be termed the Reheat Era. This does not mean that it is not a remarkable station. It is in fact probably the most remarkable plant built to date combining record low cost and low heat consumption, but it is not in the path of current popular design.

Back Tracking

As a whole, the industry backtracked ten years, discarded reheat, turned slightly to the left and joined the radical element rich in theory and short on practice. This involves the 900 to 1000 deg. F. temperature field, which eliminates reheat and makes an ideal setup for top units. At present the trend is all toward top plants, in fact it is more than a trend—it is a veritable landslide although this is of necessity a more or less temporary condition.

It is temporary because the number of stations, to which superposition is applicable, is definitely fixed both by station and system limitations. The station must be old enough so that pressure and efficiency give the top unit a reasonable share of the total output but it must not be so old that the generating and condensing equipment cannot be brought up to a reasonable efficiency and life expectancy at moderate cost. In general, this involves a pressure range of from 200 to 350 lb. in stations of from 10 to 20 yr. old. The ratio of new to old output may roughly be placed at 2 to 3. The heat economy is reduced in about the same proportion due to the efficient high pressure unit and higher boiler efficiency.

There may be cases where the heat rate alone will justify superposition but in general primary justification must be found in an increase in demand for fairly high load factor power so as to prevent robbing other stations on the system of load. It is particularly applicable to metropolitan and heavy load centers where new station sites and space are limited and expensive and for taking care of sudden load increases without making definite commitments on future extensions until it is clear what the next year or two will bring forth.

As an indication of how superposition, both steam and mercury compares with new plants, Fig. 1 and the following explanation, is reproduced from E.E.I. Publication No. D 8. In the first column the cross-hatched area shows a conventional 200 lb. steam plant in which the power produced and the fuel consumed is arbitrarily assumed as 100 per cent in order to have a basis of comparison for improvements on this cycle.

The second column shows in cross-hatched area the same 100 per cent capacity of the plant in Col. 1. Since this plant is the same except for superimposing high pressure steam boilers and turbines, the cross-hatched area above 100 per cent is the additional capacity supplied by the superimposed unit. The total cross-hatched area of approximately 158 per cent is the total power produced by the revised plant. The horizontal line at approximately 98½ per cent represents the fuel consumption of this revised plant. The additional power of 158 per cent can be produced for 98½ per cent of the amount of fuel burned in the first column by reason of the increased efficiency of the new boilers and the new cycle.

Plant Comparisons

In the third column, the cross-hatched area shows the total capacity of an entirely new plant with the same steam pressure and temperature as shown in Col. 2 but without utilizing the old 200 lb. plant. This shows a capacity of 168 per cent and a fuel consumption of about 101 per cent, as compared with Col. 1.

In Col. 4, the cross-hatched area shows the capacity of the old steam unit, the same as in Col. 1. The area above this shows a total plant capacity of 201 per cent obtainable by superimposing the mercury cycle upon the existing 200 lb. steam plant. The horizontal line at 105 per cent shows the fuel that would be consumed by this station. This indicates a material increase in efficiency due to the mercury cycle.

The fifth column shows, in the cross-hatched area, the amount of capacity, 125 per cent, that would be produced by a 400 lb. steam unit and the area above

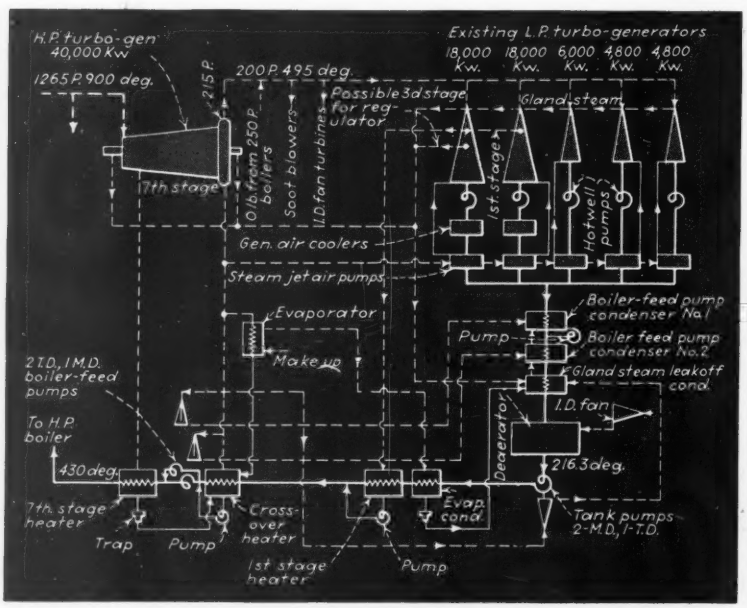


Fig. 2. Partial flow diagram of Logan Station

this shows the amount of capacity that would be produced by the mercury portion of this plant. The sum of the two, 225 per cent, is the total power that would be produced by this entirely new mercury and 400 lb. steam plant. The horizontal line at 110 per cent indicates the fuel that would be burned in this plant. All of these comparisons refer back to the 200 lb. plant as unity, as shown in Col. 1.

New Plants

Most of the new central stations listed in the preceding article are superimposed plants. Some are being built for reasons stated above, while in the case of others there were additional factors involved. For instance, Elm Street, Fisk Street and Millers Ford limited circulating water was important, while in Kentucky Avenue the sale of high pressure steam to nearby industrial plants had a decided bearing. Generalization can, therefore, be carried only to a certain point before breaking down.

For the same reason typical layouts of top plants have little meaning in a general sense much less than in a straight condensing plant because the top plant is inherently complicated by individuality of the old plant built at a time when there was little standardization. For this reason such a layout will not be attempted. Figure 2, however, shows a portion of the Logan Station flow diagram with a new 40,000 kw. top superimposed on 51,600 kw. of old turbines. In this particular case two of the old turbines are built for extraction. This is not always the case for the extraction cycle is relatively new and when rehabilitating many of the older stations the question of feedwater heating is a problem.

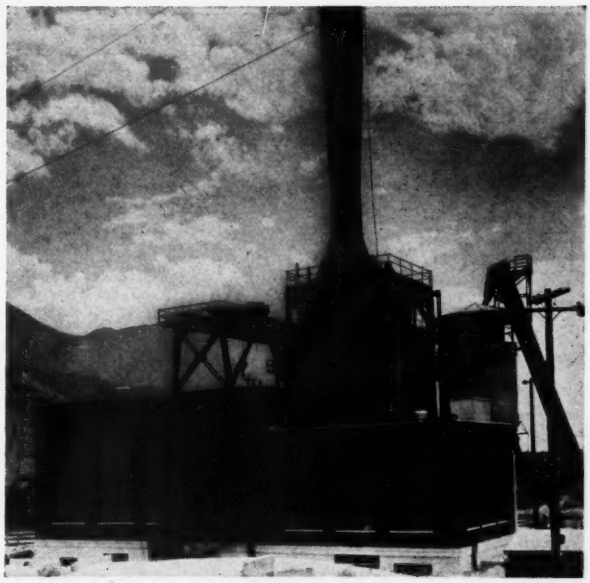
Steam driven auxiliaries are, of course, possible but the trend toward motor driven auxiliaries has been so decided and offers so many advantages that it is questionable if steam drive will ever be used again except as a last resort. At Waterside an ingenious arrangement has been worked out to handle this problem. A special feedheating turbine taking steam at crossover pressure is mounted on the main turbine shaft driving the main generator.

Old Plant Influence

Selection of top pressures and temperatures is pretty well determined by the old plant, for, the top turbine exhaust must of necessity correspond with the pressure and temperature conditions of the original equipment. This places the pressure between 700 and 1400 lb. and the temperature from 800 to 925 deg. F., the size of the installation determining the most economical conditions. The E.E.I. report mentioned above summarizes this concisely:

"With present day temperature limitations of from 900 to 1000 deg. F., the use of 1200 to 1400 lb. per sq. in. with the regenerative cycle becomes possible. The capacity of the existing station and its operating pressure and temperature are determining factors in the choice of steam conditions. It is seldom that 200 to 250 lb. stations of less than 30,000 kw. capacity can be shown to justify a top pressure and temperature greater than 700 lb. and 850 deg. F.

"With stations having an operating pressure higher than 300 lb., it will be found that a superposed pressure of 1200 to 1400 lb. and temperature of 900 to 925 deg. F. will be required if appreciable increase in capacity is to be obtained and the installation is to prove economical. With the larger stations, this pressure and temperature will be found desirable also for existing pressures of from 200 to 400 lb. In adding capacity to stations with operating pressures 400 lb. and greater, usually it will be found more economical for it to be of condensing rather than superposed type. This includes practically all those built within the past ten years."



Photo, Combustion Engineering Co.

Fig. 3. Provo Station, an 18,500 kv-a. 450 lb. single unit plant of semi-outdoor construction which saved over $100,000 in building costs

These new stations will undoubtedly be in the moderate pressure high temperature range, that is high efficiency, low heat rate stations built at comparatively low cost due to the elimination of reheat. The reasons for this are discussed at some length on pages 12 and 13 of the January, 1936, issue and need not be repeated in detail here.

Boiler, turbine and condenser considerations place the extreme limits for single expansion at 2500 lb., 1000 deg. F. on one side and 150 lb., 1000 deg. F. on the other. These two extremes represent a heat drop of 530 B.t.u. per lb. at an efficiency of 36 per cent in the first, and, 440 B.t.u. at an efficiency of 29 per cent in the second case. In between, straight expansion from 800 lb., 1000 deg. F. gives a heat drop of about 530 B.t.u. at an efficiency of 35 per cent while there are an infinite number of reheat possibilities which give an efficiency of about four per cent higher. For the immediate future at least, the moderate pressures seem to have an advantage. What the mercury plant will develop into depends to a large extent upon the performance data of the Schenectady and Kearny stations, when and if it is released, and upon the success of the two smaller mercury plants now under construction at Pittsfield and Lynn. These are mentioned more in detail later in this issue and may be looked upon as being of prime importance as far as future plant trends are concerned.

Electrical

Fig. 1. Metal clad switch and bus structure at Lakeside Station at Springfield, Ill.

TO ONE WHO has not followed development in power plant practice very closely during the past few years, the electrical features of the present-day plant may not seem to be greatly different from what they were ten years ago. In general, he finds about the same sort of equipment in use. First, there are the main generators, which he finds are still turbine driven. These have the customary shaft exciters and to all appearances are built just about the same as they were a decade ago. Next, there is the switching equipment and the bus structure; this may have a somewhat different appearance, but it performs the same services and the circuits involved are not fundamentally different. The equipment in the main control room seems to be more compact and "smoother" in general appearance, but in principle it is not greatly different from the same type of equipment ten years ago. And finally, there is the general station electrical equipment, the motors and starters and control apparatus; this does not seem to be fundamentally different except that there appears to be more of it. Transmission lines and transformers are larger, but in general they have not changed in appearance.

But appearances are deceiving, and one sufficiently interested to investigate the matter more closely would find a great difference in all of these things; indeed, he would be amazed at the progress that has been made. He would find, not only the usual refinement and improvement in detail that is the inevitable result of continued use, but he would discover startling differences in basic operating principles. New materials and new processes of manufacture will be found to have contributed to improvements in design and operation that were scarcely to be dreamed of ten years ago. For example, it would be found that the same capacity condenser which in 1924 weighed 375 lb. today, because of the use of improved paper and foil and impregnating compound, weighs only 48 lb.; also, instead of a condenser it would be called a capacitor. In one particular instance at least, the oil circuit breaker of a certain rating which only a few years ago would have required 23,000 gal. of oil, today requires only 2500 gallons.[1] Furthermore, it would be found that the entire basis of circuit breaker design would be different—it would be found to be on a much more logical and scientific basis than it was even five years ago.

Element of Control Highly Developed

The whole element of control, and here we use the term in its widest sense, will be found to be much more elaborate than it was ten years ago. The control of various elements in the station would be found to be highly coordinated through the agency of master controllers and details of operation which once were subject to manual control are now entirely automatic. Such details of operation as turbine vibration, expansion of the turbine casing, rubbing of blades and wear of the bearing, which formerly was subject to inspection and vigilance on the part of the operators, today are under the control of specially developed instruments.

Automatic control has been developed to a high degree and it is entirely possible today to build a power plant that would be completely automatic in its operation. Since it is desirable to have a certain minimum personnel in any station, an entirely automatic plant might not possess any particular advantage, but from a purely technical standpoint, it is entirely feasible. From a technical standpoint there is no reason for having human supervision in a plant, in fact in the present day plant the attendants have little to do except to check the operation of automatic devices. As a consequence, more and more control is being centralized at one point so that the entire station can be supervised by one or two men.

In some modern stations both the steam generating and electric generating control is centralized at one point, placing the entire control of the station

[1] These are the 2,500,000 kv-a. Boulder Dam circuit breakers.

Features of Modern Plants

under a single operator. All large valves in the modern stations are electrically operated.

Another feature of significance in the electrical layout of the modern station is the almost entire use of electric drive for the auxiliaries. This is to a large extent the result of the almost universal use of extraction feed-water heating which makes exhaust steam from turbine driven auxiliaries unnecessary. Today, wiith few exceptions, all auxiliaries are electrically driven, all large units by 2300 v. motors and small units by 220-440 v. motors.

Generator Practice

Concerning the main generating units, fundamentally, there has been no change in design practice. The high-speed turbo-generator has reached a high order of perfection and a degree of stability of design quite unknown in steam generating equipment. Except for improvements in materials and methods of construction, the electric generators being installed today are not, fundamentally, different from those installed ten years ago. They are more compact and of more pleasing design and many improvements in mechanical design have contributed to their greater reliability and, to some extent, their efficiency, but the generator has always been remarkably efficient as a conversion device. Electrically, the high speed generator approaches the transformer in efficiency, but the generator in addition to having the $I^2 R$ and magnetic losses of the transformer also has mechanical friction and windage losses.

It is with respect to this last loss that the greatest improvement has been made—in the reduction of the windage loss by the use of hydrogen as a cooling agent. Hydrogen has been used as a cooling agent in synchronous converters for a number of years with excellent success and the possibility of its use in generators has been under consideration for several years but until this past year no commercial installations were made. During 1936 several hydrogen-cooled generators have been under construction and it is quite apparent that this feature will become general practice in the future. The 60,000 kw. hydrogen cooled units at Windsor Station and the 40,000 kw. unit for Logan Station will be watched with great interest in this respect.

The tendency also seems to lie in the use of 3600 r.p.m. generators where 60 cycle current is used instead of the slower 1800 r.p.m. used heretofore. The most notable achievement in this direction is the 40,000 kw. unit for Logan Station which is twice the capacity of the present largest 3600 r.p.m. machine. The use of 3600 r.p.m., of course, results in a more compact machine and involves less material.

The fact that no outstanding developments in generator practice marked the year's progress is due in large measure, perhaps, to the present trend towards the use of "top" plants. As pointed out in the first portion of this discussion nearly all of the new central station capacity added last year was in the form of "top" units. The generating units in these "top" installations are necessarily of small capacity and as a consequence these units have no unusual features.

The 183,333 kv-a. unit installed at Richmond Station in 1935 is still the largest single-element generator in the world and, thus far, there has been no need of any larger units. Larger machines can and will be built if necessary, however. By the use of hydrogen for cooling, and certain other features, such as aluminum field coils and a synchronous condenser

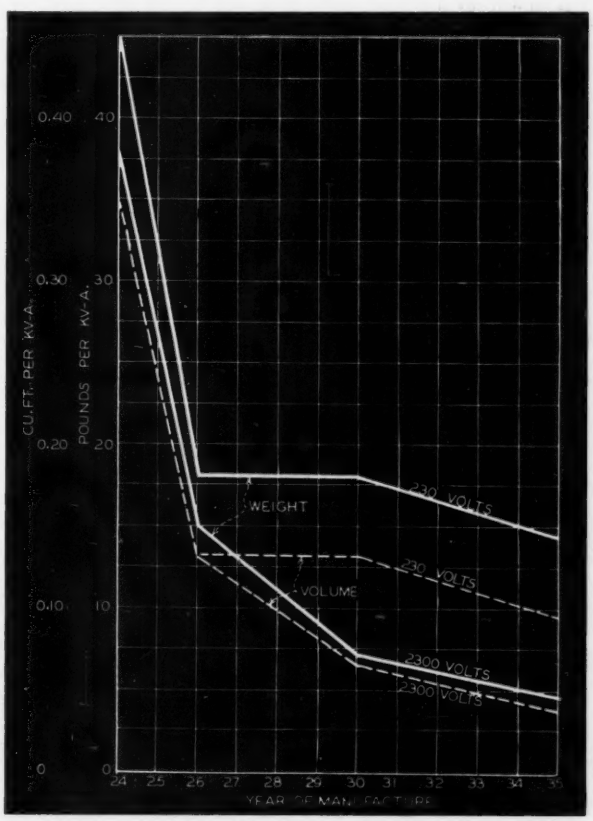


Fig. 2. Curves showing decreases in weight and bulk of 60 cycle 230 and 2300 v. capacitors, since 1924

built as an integral part of the generator, designers claim that units of 375,000 kv-a. capacity are possible. This was the picture last year and is still the same this year.

The possibility of using single generators of 375,000 kw. capacity brings into question the desirability of concentrating so much energy in a single unit. Even though some systems may be large enough to permit the use of such large blocks of power in single units, the question of accidental short circuit on the system may make it undesirable. Generators, of course, may be designed with sufficiently high inherent reactance so as to prevent destruction of the windings under short circuit conditions, but the short circuit currents of such units can cause great destruction in the external circuits as was made evident in the case of the Hell Gate short circuit in January of last year.

System Practice

The Hell Gate short circuit provided considerable food for thought. Serious as it was, it might have been far more serious and after it was all over, electrical engineers began to wonder why such an accident had not occurred before. As a matter of fact, the significant thing was not that the accident occurred but that it had not occurred before. Considering the immense concentrations of energy in such systems as that of the New York Edison Co., the infrequency of serious accidents must be regarded as high tribute to the skill of the electrical engineer in providing protective equipment.

The fact that it did occur and can again occur raises certain questions. Is it wise, for example, to continue to expand such systems in which the possibility of failure at any one point can prove so disastrous—systems in which enormous reservoirs of energy are held in leash only by virtue of the efficacy of highly intricate protective equipment? Would it not be better to direct attention to the development of systems in which the element of safety was inherent rather than subject to the operation of auxiliary devices? Or, should development proceed along present lines but with the system broken up into a number of separate units?

The possibility of replacing the present a.c. networks with some system of constant current d.c. transmission has been discussed but there is no reason to believe that even with the further development of the constant current d.c. system, it will replace the a.c. network so universally in use at present. In the meantime, no doubt, still greater emphasis will be placed on protective measures. High speed relay systems and circuit breakers provide means for quick isolation in case of trouble and these are in continual process of development. These devices do not, however, fundamentally change the picture, as regards the reservoir of energy available for destructive purposes in case of accident.

Switchgear and Bus Structure Design

There has been little actual new construction of switching facilities in central stations during the past year. In those instances where "top" units have been added, the electrical work usually involved merely the addition of a new generator panel with its associate excitation and control equipment to the existing switching equipment. Practically the only entirely new central station of appreciable size built during the year was the Lakeside Station at Springfield, Ill., which included a 10,000 kw. turbine. The switchgear at this station incorporated a number of new and interesting features. The generator is connected direct, without circuit breakers, to the low side of a 12,500 kv-a. 13,200/23,000 v. transformer with the low side delta connected and the high side wye connected with the neutral solid to ground. The transformer, switchgear and buses are located immediately adjacent to the station in a separate transformer enclosure and switchhouse. The arrangement allows practically direct connection of the transformer, through the generator circuit breaker, to the main and auxiliary buses. The main switchgear consists of six metal clad, compound-filled type breakers, of the removable lift type rated at 600 amp., 23,000 v., with an interrupting capacity of 500,000 kv-a. All main connections in the stationary units are insulated for 23 kv. and are immersed in soft insulating compound. Metal enclosures provide complete phase isolation. The transfer bus disconnecting switches are oil immersed and are of the three position type, providing a ground connection as well as a connection to the transfer bus and an open switch. These switches are operated by a lever at the front of the unit and are interlocked with the circuit breakers to prevent incorrect operation. All breaker units are completely interchangeable. Potential transformers are oil filled and are mounted on top of the structure. The

Fig. 3. Modern electrical control board showing square instruments, miniature control switches and mimic bus bars

current transformers are mounted at the rear of the unit in a compound filled compartment into which the cable terminals are connected. A housing at one end of the structure encloses lightning arresters, which are connected to the bus by means of oil immersed disconnecting switches. The doors of this compartment cannot be opened until the lighting arrester is disconnected and grounded by means of the switches.

The breakers are controlled from a small compact benchboard in the main control room. This small benchboard is equipped with flush type, miniature instruments and control switches. A miniature bus on the face of the board indicates the main connections. Views of the breakers and control benchboard are shown herewith.

This installation is described in some detail here not only because of its interesting features but because it happens to be installed in perhaps the only completely new central station placed in service last year, and to a certain extent it represents the most modern practice in switchgear and bus construction. The compactness of this metal clad equipment and its excellent safety features seem to offer many advantages over the old "open" type of bus construction and it is quite possible that future trends in switchgear design will be in this direction. It is unwise to make predictions in this respect, however. In no element of the electrical design of generating stations has there been greater change during the history of generating station development than in the bus structure and the type and arrangement of the circuit breakers used. This was partly due to the rapid growth of the industry which demanded equipment of continually increasing capacities but also to the absence of a fundamental philosophy underlying the design of this equipment. As capacities and potentials increased and the dangers from accidental short circuits multiplied, recourse was found in increased clearances. Switchhouses became large buildings with the equipment disposed over three, four or five floors. Phases were isolated from each other by masonry and concrete walls and the operating mechanism of the circuit breakers became a veritable maze of rods and levers and bell cranks. Various arrangements were attempted and no two bus structures were designed alike.

Switchgear Design on a Scientific Basis

Then from Europe came the idea of the metal-clad switch and bus structure and though its acceptance here was slow, some installations were made. In the meantime also, the circuit breaker problem received more attention and finally there came the brilliant analysis of Slepian of the fundamental action of the circuit breaker—his De-ion theory, which resulted in the De-ion circuit breaker. The oil blast circuit breaker was also developed about this time and the superior performance of these two types of circuit breaker placed design procedure on a new footing and gave new impetus to the development of switchgear. For the first time some semblance of order invaded the field of circuit breaker design.

These things occurred in the depths of the depression and there was little opportunity to put the new principles into wide commercial use, but in the meantime electrical engineers had ample time to study the situation and to formulate plans. It is of significance, therefore, that metal clad bus and circuit breaker equipment was selected for one of the first new central stations to go into service in several years.

Insofar as circuit breakers are concerned, the present De-ion and oil blast breakers have attained their highest development in the units for the Boulder Dam line. These have an interrupting capacity of 2,500,000 kv-a. and break a current of 500 amp. at 287,000 v., in less than 3 cycles. However, as pointed out in our review issue last year, the success of these breakers does not necessarily indicate that circuit breaker development will continue along present lines. The grid controlled mercury arc rectifier has demonstrated the possibility of interrupting high currents noiselessly and without the slightest disturbance to the electrical system. The possibilities of thermionic devices in the electrical field are so immense that it would be unwise to ignore their possible effect upon the future course of development. Several new types of circuit breakers have been developed and used in Europe during the past few years. Some of these are quite novel in that they use steam to quench the arc. Their principle of operation, however, is explained on the basis of the De-ion theory.

As already pointed out, fundamentally, the circuits in use in the modern station are similar to those which have been in use for years. Where the current is to be transmitted over high voltage lines and transformers are necessary, it is general practice to connect the generators solidly to the transformers and to do all switching on the "high" side. Generators are protected by differential relays and feeder circuits by overload relays. Excitation practice, today, favors the use of the shaft driven exciter and in large units the use of the pilot or sub-exciter is common.

The pilot exciter provides more rapid excitation response, an essential requirement in preserving the stability on large systems.

The tendency throughout the whole electrical system from the generator to the point of use is toward more rapid response. Interconnection makes this necessary. Before interconnection of systems was as extensive as it is today a disturbance was confined to the limits of the system on which it occurred, and after a brief interval, as the restoring forces came into action, the system would regain a stable state. Today, however, when scarcely no system is an independent entity, a disturbance on one system is rapidly communicated to adjacent systems to which it may be connected and unless prompt isolation is affected, serious instability of the entire interconnected network ensues. Naturally every effort is being made to prevent this and to this end there has been continual improvement in the design and operation of high speed relay systems and circuit breakers. Such relay systems are ingenious and make use of the latest products of electrical research. Many of them operate on carrier current, others make use of "polarity"; still others are complete metallic circuits. These relay systems are the watch dogs of the power systems; ever alert for any unusual condition they act instantly to protect the equipment from damage and destruction. They guard every element of the power system from the generator neutral to the distribution substation.

FUELS GO HIGH HAT

Coal preparation improves heat value and combustion characteristics; Oil and Gas Fuels Grow more important in Power Field.

COAL PRODUCERS now realize the importance of improving their products by artificial methods in order to maintain their markets against competing fuels that have everything in their favor except cost, and even that is disappearing in many districts.

While coal preparation has been found more essential for the domestic market than for power plants, the growing economic availability of oil and gas, particularly in the medium and small size power plants of cities, is causing many changes to take place in the marketing of coal, particularly in the sizing and cleaning to remove impurities. Operators report that small steam sizes, 2 in. and under are more easily treated than any of the other sizes. All that is necessary is to get the proper coverage and enough treating material. Costs of treating vary greatly with materials used, equipment used and in the manner in which coal is treated. Treating for special results at the mine may cost approximately 12 to 18 cents per ton, for dustless treatment at the mine from 10 to 12 cents per ton.

With these changes taking place in the treating of coals it is highly important that classification and analyses of coals from various fields be studied and tabulated as an aid to purchasers. It is no longer dependable to rely on the analyses of 10 or more years ago and a number of institutions and laboratories are at work on the preparation of new tables that will include data useful to the entire coal using field. Analyses of a technical nature, for example, would be helpful to coal companies making efforts to improve their products to the point where the most objectionable features of raw coal are eliminated. Several methods of ash removal have been developed and their success with various coals have been reported to engineering societies. By modern processes coals containing ash to the extent of 6 to 9 per cent are commercially treated so that the ash content is reduced to 4 to 5 per cent.

In a complete preparation plant of modern design, the raw coal, which is a mixture of good coal particles of all sizes and intermixed particles varying greatly in character and quantity depending upon the nature of the coal bed and associated strata, is sized into market grades of uniform-size particles or within definitely prescribed limits, and the refuse particles are removed to produce a finished product as free from impurities and as uniform in quality as the natural characteristics of the raw material will allow.

It is now recognized that in steam boiler practice it is much more essential that the coal be uniform in ash and sulphur content, heating value, and ash fusion temperature than to be low in average ash and sulphur content and high in average heating value and ash-fusion temperature. The fuel burning equipment and furnace of any boiler can be constructed to burn almost any type of coal efficiently but the highest boiler rating and efficiency and the lowest maintenance costs can be obtained only when the coal supplied conforms closely at all times to the standard of qualities for which the equipment and furnace were designed. To maintain this uniformity is the purpose of preparing coals for power plant use.

Methods of testing coal for grindability are still being investigated. The Bureau of Mines method known as the ball-mill method, was accepted as tentative standard. Then the Hardgrove method, which employs a ring-and-ball machine, met with favor and was recommended by many. The latest to receive recognition is the C.I.T. roll-test method in which a sample of sized coal is placed on a flat steel plate and is crushed by rolling a heavy steel cylinder over it 10 times. The crushed product is then screen-sized and the new surface produced is calculated from the screen analysis. Results of an investigation conducted by H. F. Yancy and M. R. Geer and reported to the A.I.M.E. showed that coals are mixtures of components, each of which requires a different amount of energy to grind. Relative grindability results cannot be accurate unless equal proportions of these components are ground to the same size suitable for use as powdered fuel. This, it is reported, is accomplished by the ball-mill procedure, but not by either of the constant-work methods. With the latter type only the less resistant or softer components are ground; consequently, the relative grindability values obtained do not represent accurately the grindability of the total sample.

Reports have been made on investigations with very finely pulverized coals, minus 200-mesh material, in an effort to discover methods of removing fusain, which is non-caking and the most friable ingredient in bituminous coal. It is contended that the coking

properties of the fine sizes of Illinois coals may be improved by dedusting in which process the fusain is largely removed. Pneumatic processes of removing fine materials is increasing in the preparation of stoker size coal. Fusain is a principal ingredient of this dust.

Announcement is made by the American Society for Testing Materials that a method is being prepared for testing the dustiness of coal and coke. This is deemed desirable in order to determine the efficiency of treating coal and coke with chemical and oil compounds to allay dust and give a clean fuel. Also, the present standard method of sampling coal is being revised by the A.S.T.M. This revision gives a detailed procedure for the rapid reduction of gross samples of coal to a convenient quantity for transmittal to the laboratory. This is accomplished by mechanical methods of crushing and by riffle samplers. It is believed that this mechanical method of reducing coal samples will be widely used by coal producers and consumers who have occasion to do much coal sampling, as the method is much more rapid and is less expensive than the hand method described in the present standard method.

Users of coal have long known that the characteristics of the ash place many limitations on the choice of burning equipment, the furnace design and combustion conditions that must be maintained. Until recently about all the scientific information available regarding the fusion of ash was the temperature at which this condition takes place with various coals. Not satisfied with this meager information, an entirely new method of determining fusion temperatures and characteristics of ash at temperatures below that of the melting point has been used by test engineers of the Northern States Power Co. which, it is hoped, will enable the classification of coals along lines helpful in the selection of fuels for specific furnace equipment. The method employs microphotographs taken at various known temperatures up to the point of complete fusion. Examination of these photographs reveals the clinker-forming characteristics of the coal and other factors that enter into the problem of burning coal in boiler furnaces.

From England comes a method of dividing streams of air-borne powdered coal so as to secure even distribution. The device which was exhibited at the Physical Society's Exhibition has, at the dividing point, a checker work of ducts, alternate openings in which lead to the separate branches. The method is reported to be in successful use for firing separate boiler furnaces.

During the year operating experiences with pulverized Texas lignite in the Trinidad steam-electric station, operating on a base load, have been reported. The original plant was started in 1926 but the remainder of the station was not completed until 1931. This station was not only the first large plant to use Texas lignite but also the first to use it in pulverized form. After 10 yr. of operation the engineers in charge report that lignite as a fuel compares favorably with fuel oil and natural gas during a period when there has been a very large flush production of each within the state.

Furnace designers of Germany have been making studies of equipment for burning low-grade coal con-

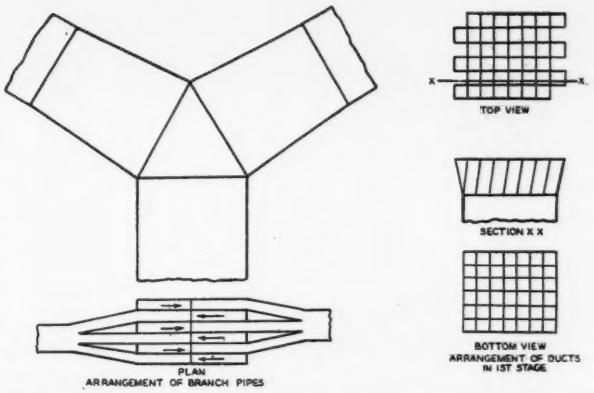


Fig. 1. Device for delivering uniform mixtures of air and pulverized coal in two-way distributor

taining 62 to 63½ per cent moisture and having a heat content between 2880 and 3060 B.t.u. per lb. but with ash content only 2 per cent. The fuel is introduced onto a steep front oscillating section of the stoker through a shaft extending the full width of the grade and the stoker is divided transversely into four sections, each driven independently and supplied with its own blower. Boiler efficiencies as high as 77 per cent have been obtained.

Research Extending Oil Reserves

Technical advance in discovery, production and refining of petroleum have added greatly to the availability of oil reserves in the past few years. Credit should be given to research for pointing the way to make crude oil and gas yield higher precentages of desirable products than formerly by polymerization, hydrogenation solvent refining and controlled stabilization in the manufacture of national gasoline.

In the burning of fuel oil, it has become well recognized that the proper temperature for atomization needs careful consideration for by controlling the temperature, the specific gravity at the burner can be maintained at that which is most suitable for atomization. Recognition of this has caused many engineers to place little importance upon the specific gravity specification of the fuel oils they purchase. It does, however, have a bearing upon the heat requirements, for the higher the specific gravity the less heat is required to condition the oil for atomization. The quality now favored for determining the proper temperature to use is the viscosity. The most favorable viscosity has been determined by the U. S. Navy to be between 2 and 4 deg. Engler, with the best point about 3.2 deg.

Fuels for Diesel engines are being given considerable thought and the following tabulation of fuel specifications was given at the Midwest Power Engineering Conference by T. M. Robie as being suitable for present day engines employing solid injection and operating at speeds above 500 r.p.m.:

1. Distillation (End Point), max. 700 deg. F.
2. Cetane number, 40 to 70
3. Conradson carbon, max. 2.0 per cent
4. Viscosity Saybolt, at 100 deg. F., 35-75 sec.
5. B.S.&W., max., 1.0 per cent
6. Sulphur, max., 1.5 per cent
7. Pour Test, 15 deg. F. or as required
8. Ash, max., 0.05 per cent
9. Flash C.O.C., 140 deg F. or legal
10. Gravity A.P.I., 30 to 40

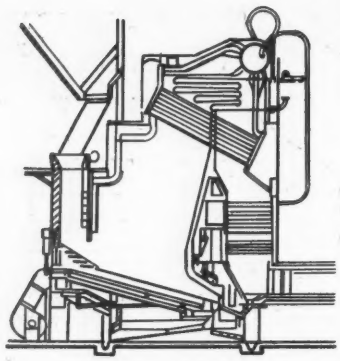


Fig. 2. German furnace for burning high-moisture coal

For engines with operating speeds below 500 r.p.m. and where centrifuging and preheating is not desirable, the specifications could reasonably be modified somewhat as follows:

1. Distillation, 95 per cent at 700 deg. F.
2. Cetane number 40 to 70
3. Conradson carbon, max., 2.5 per cent
4. Viscosity Saybolt U., 100 deg. F., 40-100 sec.
5. B.S.&W., max., 1.5 per cent
6. Sulphur (2 cycle), max., 2.5 per cent
   (4 cycle), max., 1.5 per cent
7. Pour Test, 15 deg. F. or as required
8. Ash, max., 0.1 per cent
9. Flash C.O.C., 140 deg. F. or legal
10 Gravity A.P.I., 25-35

Some foreign experiments with colloidal fuels have been reported in which investigators state that the keeping of the powdered coal from settling out of the oil presents the greatest difficulty. They find it essential either to incorporate some chemical in the oil or to treat it in such a way that it tends to set as a jelly when at rest, but behaves like a liquid when pumped or agitated. Sodium-stearate soap has been used for this purpose. This fuel has been used in Diesel engines and in boiler furnaces.

New Market Opened for Natural Gas

By the completion of a steel pipe line from the Texas gas field to Detroit, Mich., a distance of 1152 mi., another district is now being served with natural gas. This line is planned to deliver 90,000,000 cu. ft. per day to the Detroit utility which maintains a terminal mixing and distributing plant, with local pipe lines for connection with the present system in the metropolitan area. From this transmission pipe line natural gas will be available for Indianapolis, Dana and Zionsville, Ind.

In Chicago, the Palmer House uses gas from the Texas fields in summer, April to October, taking advantage of a low seasonal rate at a saving in fuel costs per 1000 lb. steam over coal, of $0.276 to $0.33. Oil burners are used on the same boiler in winter. Oil and gas burning give a flat boiler efficiency curve over a long range and during the winter this boiler is operated to take the swing of the load, while the base load is carried on coal-fired boilers.

One of the outstanding applications of sewage gas for power purposes is the installation at Peoria, Ill., which went into service in 1936. The sewage from the Sanitary District of Peoria, after being separated from the liquids, is pumped into large digestion tanks in which the gas is generated. A typical analysis of the gas is: Methane, 60 to 65 per cent; carbon dioxide, 32 to 38 per cent; nitrogen, 2 to 3 per cent; and hydrogen sulphide, 50 to 100 gr. per 100 cu. ft. The net heat content of the gas runs from 500 to 600 B.t.u. per cu. ft. This gas is used as fuel in a 300-hp. gas engine which furnishes power for the pumps and blowers necessary for the operation of the sewage disposal works.

Another application of this kind of gas is for running a 40-hp. gas engine at Palo Alto, Calif., to supply the power for the sewage treatment plant. The Los Angeles County Sanitary District is using a 200-hp. gas engine and Ontario, Calif., is using a 4 cyl. 6½ by 8½ in., 600 r.p.m. engine. All run on digester gas made from sewage.

One of the newer fuels on the market is butane, sometimes called bottled gas, made from oil well casing head gas. This is a volatile fuel, maintained as a liquid under pressure, is stored like gasoline and is priced at about 6 cents a gallon in parts of California where it is used for heating, cooking, power purposes, automobiles and, because of its volatile characteristics, as a refrigerating agent. As a fuel it consists of a blend containing 25 per cent propane, 50 per cent isobutane and 25 per cent normal butane. In one installation, this fuel is stored at 60 to 80 lb. pressure, on its way to the burners it expands through refrigerating coils, reaching the burners at 3 to 7 lb. pressure.

An event of importance to industry in the use of fuels was the Industrial Fuels Conference held in Jersey City, N. J., under the auspices of the Department of Smoke Regulation of Hudson County. This was an experience meeting at which men in charge of boiler plants, in which many types of fuel burning equipment are installed, gave their operating results. New and old types of equipment were compared as to cost, efficiencies secured, convenience in operation and smoke making characteristics. Coals of various grades and classes were compared with each other and with oil fuel. The results of this conference were so helpful to fuel users that a permanent organization has been formed known as the Industrial Smoke Abatement Association of Hudson County whose purpose is to combat air pollution by the promotion of better combustion through educational and coöperative methods.

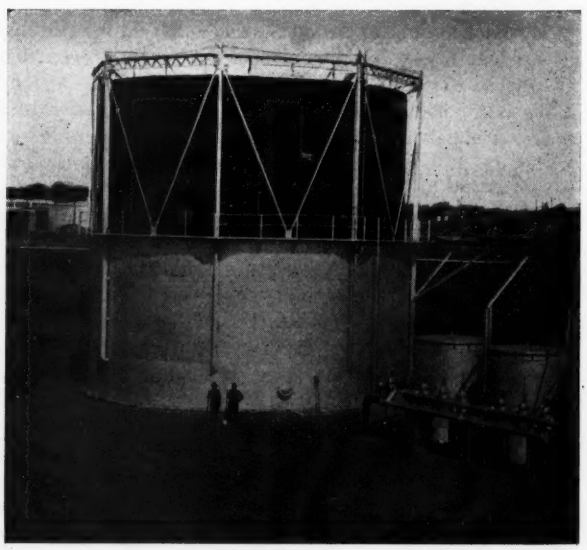
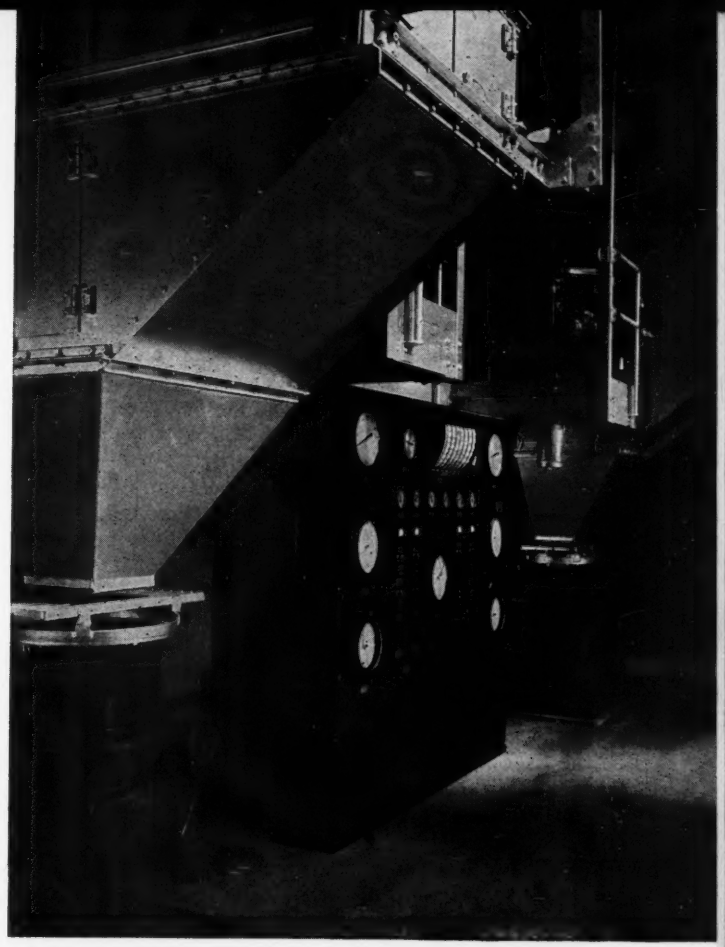


Fig. 3. Holder for gas generated from sewage which supplies fuel for Peoria plant

New building program finds boiler design still in state of flux. Logan, one of the first of the new stations, starts the race with a 1,000,000 lb. per hr. unit. Forced circulation and mercury boilers still under intense development.



Boiler control panel, Lakeside Station in Springfield, Illinois

Photo, The Hagan Corp.

STARTING FROM A MILLION

IMPORTANT DEVELOPMENTS of the next few years will undoubtedly center in the boiler room, or to be more explicit, in the boiler itself. As far as efficiency is concerned, there is little to be expected because the margin of possible improvement has for many years been small, but the sudden trend toward high temperatures has started a readjustment that may well take several years to accomplish.

High temperatures make the superheater the dominant element of design. The surface has to be increased and the elements located nearer to the furnace, in fact separated from the furnace only by a slag screen. The high temperatures involved make more accurate temperature regulation necessary adding another problem to the shoulders of the already harassed designer.

On the other side the importance of the water wall is steadily increasing so that the boiler proper is being slowly but steadily crowded out until it now serves as little more than a skeleton around which to hang the component parts of the steam generating unit. Both the straight tube and bent tube conventional designs have proven themselves well adapted to pressures up to 1500 lb. and this country shows no tendency to abandon these basic designs in spite of reported gains in Europe for such types as the Loeffler, Siemens, Benson and Velox.

For many years the industry in this country has been working toward a single boiler-single turbine plant and boiler availability has steadily increased until this is considered thoroughly practical by a large share of the industry. This is shown by the large number of single boiler top plants being installed. In addition to the space limitations which must be met in these rebuilt plants, there is the element of cost which cannot be overlooked and which is sufficient to cause a continued trend in the direction of large units for both top and new stations.

Price vs. Size

This price incentive is forcefully brought out by the following summary of a discussion (by John Van Brunt of Combustion Eng.) before the A.S.M.E. Assuming a base cost of about 1000 lb. of steam from a 100,000 lb. per hr., 450 lb., 775 deg. F. boiler as unity, costs for larger sizes would be as follows:

100,000 lb. per hr. boiler, unit cost	1.00
200,000 lb. per hr. boiler, unit cost	.70
300,000 lb. per hr. boiler, unit cost	.60
400,000 lb. per hr. boiler, unit cost	.55
500,000 lb. per hr. boiler, unit cost	.525
750,000 lb. per hr. boiler, unit cost	.50
1,000,000 lb. per hr. boiler, unit cost	.485

While these figures are for 450 lb. pressure, the rates will be about the same for higher pressures. One of the factors in this cost relation is the engineering and design costs of modern units.

To design and detail a complete 100,000 lb. per hr. unit, including boiler, furnace, water walls, superheater, economizer, air heater, fuel equipment, fans and ducts, is said to require from 8000 to 10,000 drafting hours at a cost, including supervision and engineering, of from $25,000 to $30,000. A 300,000 lb. per hr. unit will require but little more and a 1,000,000 lb. per hr. unit perhaps 15,000 hr.

Million-pound Boilers No Novelty

Now a million pound per hour boiler is a large unit, comparable to a 100,000 kw. generator, and although the East River boiler has produced 1,270,000 lb. per hr. of steam, the River Rouge boiler was designed for 900,000 lb. per hr., and one Kips Bay boiler has averaged 805,000 lb. per hr. for a month, the new 1,000,000 lb. per hr. unit going into Logan Station is a matter of some import to the industry. A cross section of this unit is shown by Fig. 2. It is tangentially fired by pulverized coal and is the initial step of the utilities toward ultra-sized modern boiler units.

The furnace is 37½ ft. wide, giving a capacity of 26,660 lb. per ft. of width, which is quite conservative considering that the River Rouge boiler mentioned above, built to column space limitations originally intended for 250,000 lb. per hr. units, has a steam output of 35,156 lb. per hr. per foot of furnace width. Built as single units, either of these boilers would have meant radical departure in design to avoid an excessive draft loss or a long narrow furnace not adapted to tangential firing. These double boiler units are primarily for large capacities of from around a million pounds per hour up. Below this the single type unit is applicable although the ultimate size is not yet fully determined.

Rebuilding old stations at minimum cost is often a complicated problem involving unconventional designs. For instance, the boilers installed at West End, and shown by Fig. 3, were designed to fit in the original column spacing with minimum changes in the building steel. They are designed for 350,000 lb. per hr. each, 1450 lb., 925 deg. F. The economizer and superheater section is divided vertically by a baffle with the damper at the top to control the superheat by varying the gas flow over the superheater elements.

Superheat control is necessary on these high temperature units. Control by means of combination, radiant and convection surface as at Port Washington, or by means of single or double desuperheaters sprays has not found wide favor in the present phase of American practice and the damper arrangement, in principle used at Edgar a decade or more ago, and further developed at Trenton channel, has become accepted practice. It is simple, cheap, effective and subject to automatic control.

Drums and Alloy Steels

In addition to the major changes necessitated by the increasing importance of superheaters and water walls, there are numerous cost and construction details which influence design of the newer units. Drums are expensive and are held to small size and minimum number in the high pressure units. In Europe the two drum design has been favored for some time and recently even the lower drum has been replaced by a header. In multipass designs, the same tube bank may run through two passes.

In this country, as well as in Europe, the early high pressure boilers used forged drums. Under the A.S.M.E. Boiler Code rules of 1927 and 1929, two classes of steels, Class I with a tensile strength of 60,000 lb. per sq. in. and Class II with a tensile strength of 75,000 lb. per sq. in. were allowed, most of the drums coming within the latter class. Originally these drums had forged heads, the cost of which often ran as high as the entire cylindrical portion. Code revisions made in 1934 permit the formed ends to be welded to the ends of forged cylinders. In Europe forged drums are still used almost exclusively for pressures of over 900 lb. and a 100,000 lb. per sq. in. tensile strength

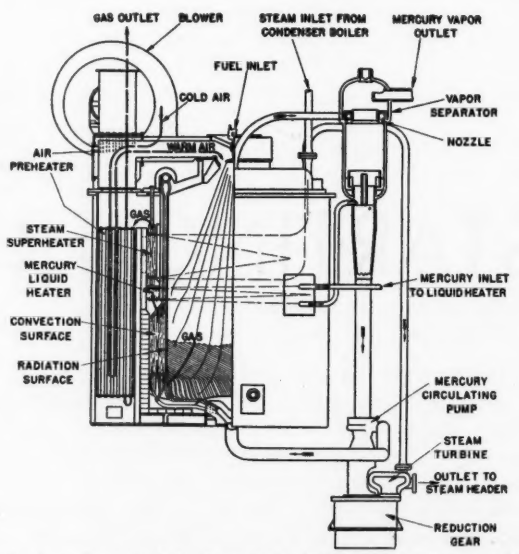


Fig. 1. Arrangement of the forced circulation mercury boiler at Lynn

steel is used, thus giving thinner walls and lighter drums than in this country.

The introduction of welding, under Boiler Code rules, in 1931 changed the picture materially, although design calculations were at first limited to 55,000 lb. per sq. in. tensile strength. In 1934 this was increased to 70,000 for moderately thick plates and 65,000 for the heaviest, the carbon being limited to 0.35 per cent and the manganese to 0.9 per cent. More recently, in 1936, approval has been given to alloying the low carbon steel with 0.25 to 0.60 per cent molydbenum, which increases the cost somewhat but gives a more ductile weld and improves the workability of the plate. The cross drums of the Waterside boilers and the

drums of the Logan boilers are built with this alloy steel. At present there is a demand for the approval of special steels running up to 85,000 lb. per sq. in.

German practice sanctions superheater and boiler tubes about half as thick as American practice, the thickness being based on a factor of safety of but 1.8 at 750 deg. F. Superheater elements for temperatures up to 800 deg. F. are commonly copper-molybdenum steel. For temperatures of 800 to 850 deg. F., a chromium-molydenum steel for the second or high temperature section and for temperatures of over 850 deg. F. all chromium-molybdenum steel, is common

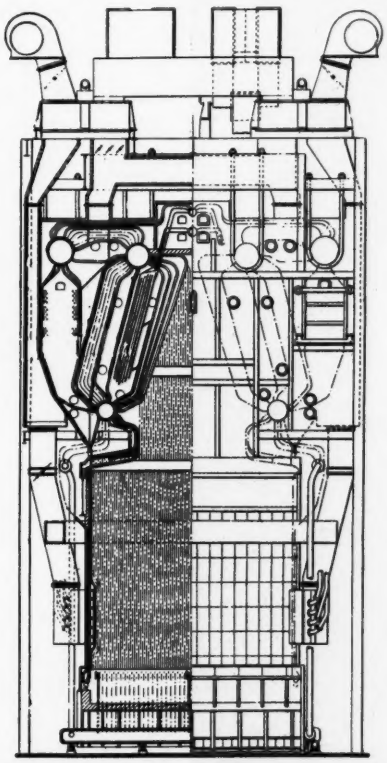


Fig. 2. Logan Street, a million pound per hour, 1425 lb., 925 deg. F. double boiler installation to supply steam for a 40,000 kw. top turbine

practice, although two earlier 880 deg. F. German installations used low carbon and nickel steel tubing which had to be replaced only after 20,000 and 25,000 hr. respectively. Tests in England indicate that there should be a reduction of one-third in the permissible strength when going from 900 to 965 deg. F. and that above 900 deg. F. the creep strength of 1 per cent chromium steel is less than ½ per cent of molybdenum steel containing no chromium.

Radiant superheaters are not widely used in this country and have made little practical progress in Europe, although the present practice of placing convection elements so that they are but lightly screened by boiler surface gives the same effect and flattens the superheat curve due to the combination radiant-convection heating effect. To keep the metal temperatures low, superheat velocities are kept from 45 to 55 ft. per sec. for pressures up to 600 lb. and from 35 to 45 ft. per sec. for higher pressures. For good distribution, it is becoming standard practice to distribute the saturated steam connections over the entire length of the drum.

Forced circulation and forced flow boilers such as the Lamont, Velox, Loeffler, Sulzer and Benson are making steady headway in Europe, and the Steamotive, a new design under development in this country, offers interesting possibilities. Additional details are given in the next article. The variable pressure operation of

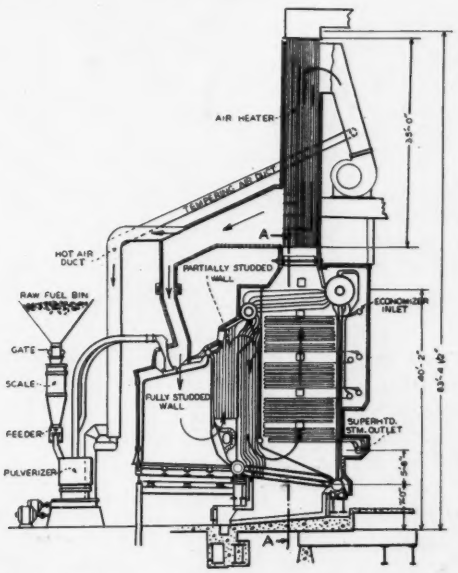


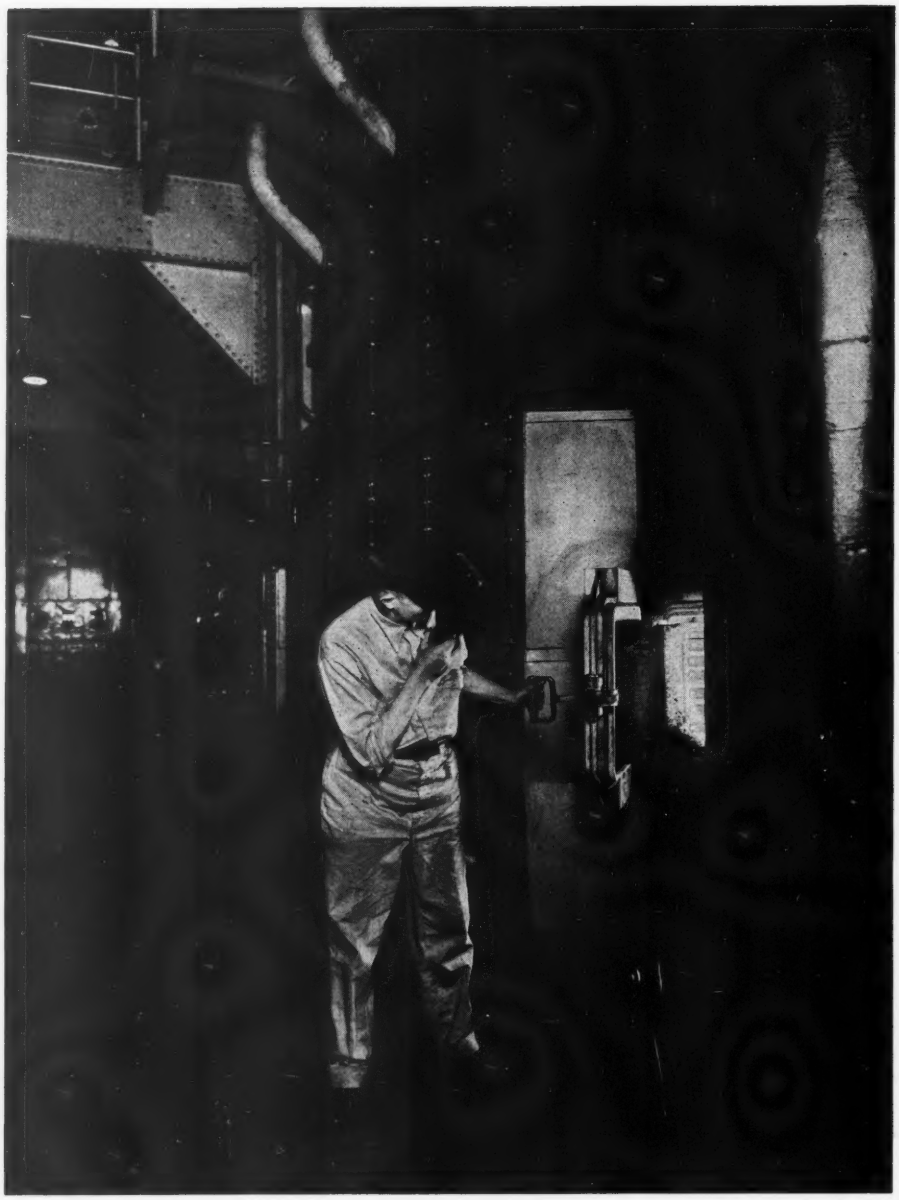
Fig. 3. West End Station, a design incorporating slag tap furnaces to meet the space restrictions of rehabilitation, capacity 350,000 lb. per hr. at 1450 lb. 925 deg. F.

the Benson has extended its scope, and one of the most recent being a 1200 lb., 880 deg. F. installation of four 53,000 lb. per hr. units, for the liner Potsdam.

In connection with unconventional types of boilers, the work being carried on at Lynn and Pittsfield, Mass., on the new mercury boilers must not be overlooked. These embody design modifications resulting from experience with the earlier Hartford, Schenectady and Kearny installations. In each of these smaller units the 1000 kw. mercury turbine exhaust will supply 12,500 lb. per hr. of 185 lb. ga. steam or sufficient to generate an additional 900 kw.

At Pittsfield the boiler is of the natural circulation type with tubes similar to the liquid mercury cooling walls at Kearny and Schenectady. The Lynn unit, Fig. 1, is of the forced circulation type with all the heating tubes filled with liquid mercury, the vapor being formed in a separate chamber by a 200 lb. drop in pressure. This arrangement was adopted to eliminate the transition zone from liquid to vapor in which difficulty with wetting the metal surfaces has been encountered.

Design sketches of a 44,000 kw. unit have also been made. This boiler eliminates the dead end porcupine tubes and has but a single drum. The furnace is cooled entirely by liquid mercury tubes, with a vaporization zone in the upper portion of the tube. Gases of combustion pass through a liquid heater, steam superheater and air heater on their way to the stack. It is expected that the new designs will reduce the amount of mercury necessary to about 6 lb. per kw.



Photo, The Detroit Edison Co.

Furnaces Take The Lead

Increasing importance of water walls robs boiler of a considerable portion of the small margin of work left by superheater, economizer and air heater. Heat absorption in furnace runs up to as high as 42 per cent of the total. Three types of firing in general use. Both air heater and economizer usually advisable to obtain acceptable performance. Compact forced circulation unit with heat release of 400,000 B.t.u. per cu. ft.

FURNACE DESIGN cannot be considered apart from the boiler because both are inseparable elements of the much broader term steam generating unit, comprising furnace, water walls, superheater, boiler economizer and air heater. As the extraction cycle cut into the work of the boiler from the feedwater side, it seemed that the economizer might well pass from the picture, leaving the air heater to carry on the work of low temperature heat recovery from the flue gases.

Without high temperatures and developments in water wall construction, such a change would undoubtedly have taken place. The increasing importance of waterwalls did, however, reduce the needed boiler surface. The nearness of the superheater to the furnace increased the gas temperature leaving the coils and the increasing feedwater temperature decreased the work of the boiler. The resulting boiler surface spread thin offered cost, structural and circulation factors which made it difficult to distribute so

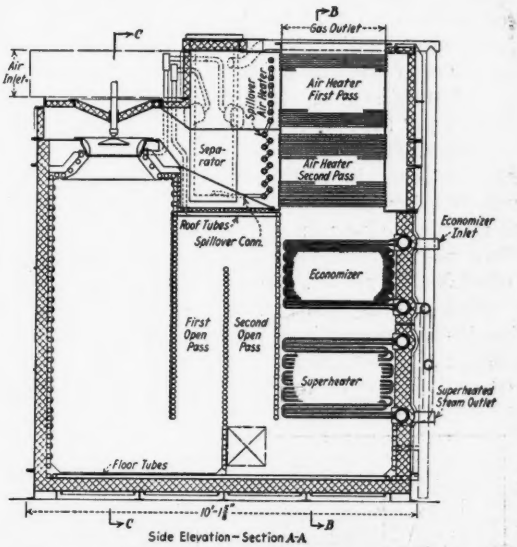


Fig. 1. The latest development, the Steamotive. A heat liberation of over 400,000 B.t.u. per cu. ft. is reported with oil. A unit for horizontal firing has also been developed and two locomotives are being built for the Union Pacific Railroad

as to reduce the flue gas temperature to a point where it could be properly handled by an air heater alone. As a result the steaming economizer came into favor. In bent tube boilers this surface is often built integral with the boiler with directional flow by internal drum baffling, in other types it is usually of the separate forced flow type.

The present status is well summarized in Trends in Design of Large High Pressure High Temperature Boiler Units (May, 1936, Combustion) as: "Boiler, economizer and air heater surface may be used, within their limitations, separately or collectively, for absorbing the residual heat in the products of combustion leaving the superheater. Considerable latitude is permissible in working out the most economical arrangement. Boiler heating surface alone is never sufficient for efficient results. With a saturated steam temperature well above 500 deg. F., an outlet gas temperature of something over 650 deg. F. would be the practical minimum. Economizer surface alone will seldom be sufficient. The entrance feedwater temperature will be, in practically all cases, well over 300 deg. F. and may be in excess of 400 deg. F. With a minimum excess temperature of gas outlet over that of water inlet of 150 deg. F., the final gas temperature will be from 450 to 550 deg. F. or more. To bring the final gas temperature to a value below 450 deg. F. an air heater is an essential element of equipment. It is conceivable that an air heater alone would be equal to the total task; actually, however, it must be supplemented with boiler or economizer surface to obtain an acceptable overall performance."

Most of the recent large installations have been for pulverized fuel from unit mills, three general methods of firing now being in vogue: Horizontal firing as used in Fig. 6; tangential firing as shown by Fig. 3, the modern development of the well type furnace from Huntley; the inclined or vertical firing as shown by Fig. 5, used at State Line and later at Buzzards Point with slag tap furnaces in order to obtain a reduction of slag and cinders by impingement on the bottom.

Heat Absorption

The first two follow more or less conventional lines while the second seems to offer greater variety in the way of boiler, economizer and superheater surface, approaching in fact the old Dutch oven brought to date by water walls. West End (see preceding article) and Fisk Street are excellent examples of this type of construction. In the latter a comparison of heat absorption in the various sections is of interest, as it shows rapidly increasing importance of the water wall and superheater sections.

In these two boilers, each with a continuous rating of 375,000 and a peak of 412,500 lb. per hr. of 1490 lb., 910 deg. F. steam, heating surfaces are distributed as follows:

Furnace	5,070 sq. ft.
Boiler Section	6,640 sq. ft.
Superheater	19,800 sq. ft.
Economizer	12,000 sq. ft.
Air Heater	56,200 sq. ft.
Total	99,710 sq. ft.

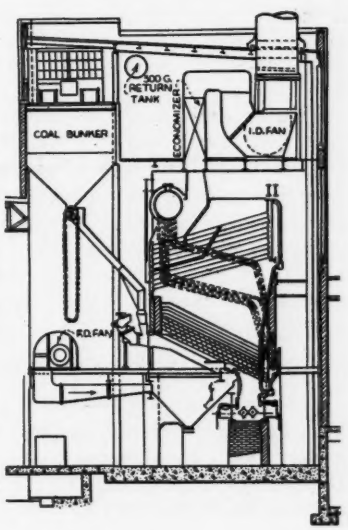


Fig. 2. Modern water walls mean much to the stoker fired industrial boiler furnace. A 100,000 lb. per hr., 300 lb. unit at the Michigan Carton Co. plant. Provision is made for the later addition of superheater elements

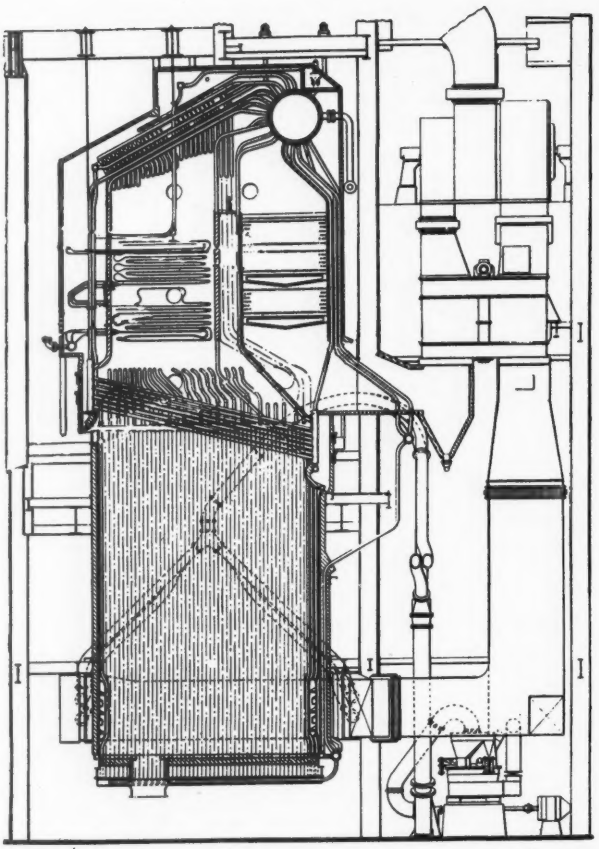


Fig. 3. Waterside No. 2 will have two 500,000 lb. per hr., 1400 lb., 900 deg. F. boilers

On a heat absorbing basis, however, the comparison is more striking. These values are:

Furnace	42	per cent
Boiler	12	per cent
Superheater	25	per cent
Economizer	13.5	per cent
Air heater	7.5	per cent
Total	100.0	per cent

Thus the furnace walls with 5070 sq. ft. absorbs three and a half as much heat as 6640 sq. ft. of boiler surface, or, on a unit basis, over 450 per cent as much per square foot. The heat release will be 31,600 B.t.u. per cu. ft.

Water walls are by no means limited to pulverized fuel fired furnaces, two western plants, Provo and Omaha, both using somewhat similar bent tube boilers fired by chain grate stokers. A cross section of the Omaha unit, 255,000 lb. per hr. fired by a 570 sq. ft. stoker to supply 1200 lb. 900 deg. F. steam is shown by Fig. 4. The Provo unit, for 450 lb. 760 deg. F. operation is rated at 200,000 lb. per hr. and supplies a single 18,750 kv-a condensing turbine.

Water Cooled Stokers

The water cooled stokers announced last year have been further developed and three installations are well under way. The largest is for a 300,000 lb. per hr., 750 lb., 765 deg. F. unit for Cedar Rapids, where the original work was carried out. Other units are going into the municipal plants at Rochester and Austin, Minn. Both of these plants will use water cooled underfeed stokers wth the furnaces designed for burning both coal and natural gas. This opens up an entirely new field for coal, as formerly oil had a monopoly on standby service for natural gas plants. The development is important, as a cheap standby fuel enables the power plant to make wider use of dump gas from the ever widening system of natural gas lines, under an arrangement of mutual advantage to the gas company and consumer.

Just announced before the A.S.M.E. as the cooperative development of three manufacturers, a new type of steam-generating equipment named the Steamotive is of unusual interest. In it, steam is generated at high pressure and temperature, under fully automatic control in response to changes in demand. The units are intended for capacities of from 2000 to 10,000 hp. Two such units have already been built. The first, now in service in the Lynn, Mass., works (of General Electric) is used to test marine and other small turbines. It has an output of 21,000 lb. per hr. of steam at a pressure of 1500 lb. Another, a completely co-ordinated power-generating plant incorporating the Steamotive and turbine-generator, with a capacity of 10,000 lb. per hr. and furnishing steam to a turbine at 1200 lb. and 950 deg. F., is being installed in a small, isolated plant of a large industrial concern to supply electric power and low-pressure steam for building heating. Both units are oil-fired.

Two oil-fired Steamotive units, each with a capacity of 40,000 lb. per hr., are now being constructed for the Union Pacific Railroad for driving two 2500 hp. turbo-electric locomotives, using steam at 1500 lb. and 950 deg. F.

Objectives sought in the design of the new equip-

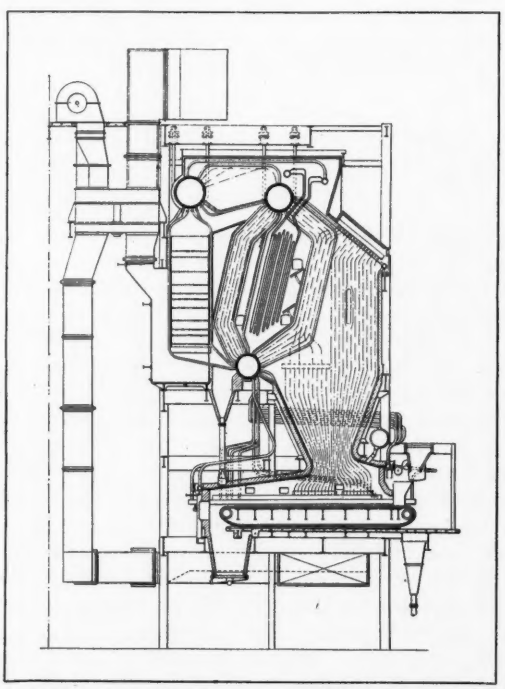


Fig. 4. Omaha Steam Plant has one new 255,000 lb. per hr. 1225 lb., 925 deg. F. unit fired by a 570 sq. ft. chain grate stoker. The furnace is water cooled

ment were: Minimum weight and size per unit of steam produced; wide range of capacity with ability of the unit to respond quickly to wide variations in load conditions; adaptability to wide range of fuels; completely co-ordinated auxiliaries; completely co-ordinated automatic control, and units of simple design constructed in sizes small enough to be portable.

Auxiliaries, geared together as one turbine-driven unit, in the case of the unit at Lynn, consist of a feed pump delivering 25,000 lb. of water per hr. at a pressure of 2000 lb., a blower for 30,000 lb. of air per hr. at 60 in. water pressure, a fuel-oil pump, and a lubricating-oil pump.

In the operation of the Steamotive unit, the flame and gases pass from the burner through the completely water-cooled furnace, thence into the superheater. flowing around the separator, through the economizer and air heater, and up the stack. The air for combustion leaves the blower at relatively high pressure, passing through lanes intersecting the stack, and down around the air-heater tubes to the oil burner. There is no induced draft fan, the blower forcing the air through the burner and furnace under pressure.

Feedwater enters the economizer inlet header, and, after leaving the outlet header, is divided into several circuits, all of which form the floor, sides, and roof of the furnace, as well as the sets of loops forming the boiler screen. All the steam is generated in these furnace and boiler circuits, and enters the separator with a surplus of water in each circuit. From the separator, the dry steam goes through the superheater, and directly to the main turbine. The water from the separator is called the spillover, and it passes through a heat exchanger to the hot well, where it mixes with the condensate, and is refed to the boiler by the feed pump.

Elimination of refractory in the furnace and boiler setting, replaced by waterwalls and insulating block, not only results in a large saving in weight and volume, but also in reduced heat capacity that materially affects the ability to change output quickly. The small water content of the forced-circulation boiler results in quick response to load changes and insures safety in spite of the high-temperature and high-pressure steam conditions. These factors permit quick starting from a cold condition, requiring less than 10 min. from lighting the burner to full output. It has been found that combustion liberation rates up to 400,000 B.t.u. per cu. ft. per hr. can be obtained with low excess air and smokeless combustion with oil fuel. The pressure furnace which utilizes forced draft only is entirely practicable and materially simplifies the draft equipment and control therefor.

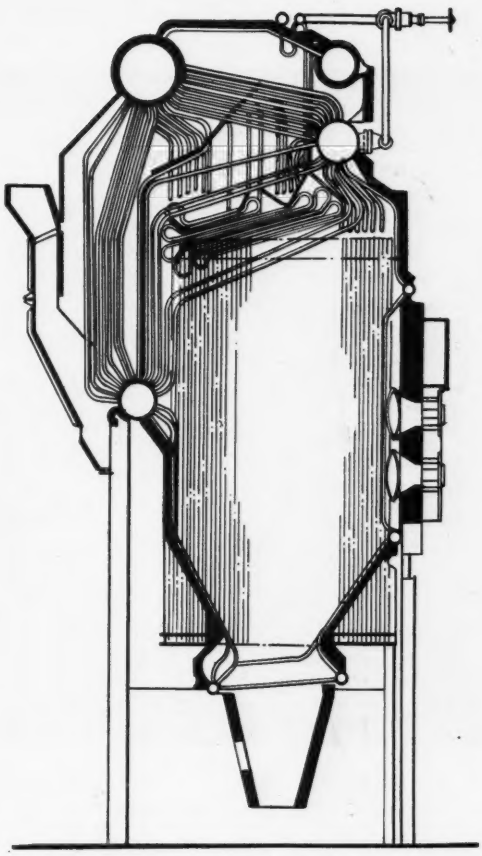


Fig. 6. Horizontal firing is used on the 205,000 lb. per hr. 430 lb., 910 deg. F. unit for Lynn Gas & Electric Co. latest addition

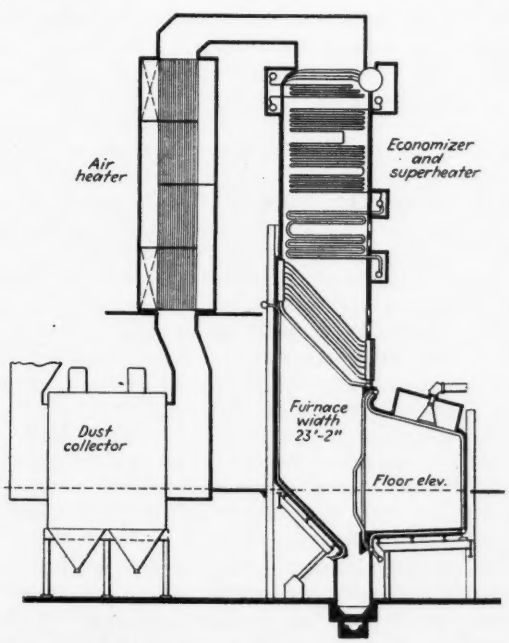


Fig. 5. The 325,000 lb. per hr., 1275 lb., 910 deg. F. unit at Fisk Street uses vertical firing and a two slage furnace. This increases the fluidity of the ash for slag tapping and minimizes tube fouling

The wide-range burners used on this unit and the co-ordinated auxiliary set make complete automatic control a thoroughly practicable device as has completely automatic lighting of the burners.

It is essential that the application of a unit of this character be carefully considered, since reduction in weight and space requirements can only be obtained through increase in auxiliary power and reduction of plant efficiency, especially at high loads. In certain applications the problem is simple, since the space requirements are definitely fixed. However, where space is available, it is generally more economical to use a larger unit, improve boiler efficiency, and reduce auxiliary power.

Feedwater

Photo, The Detroit Edison Co.

Basic problems of scale, corrosion, embrittlement and carry-over unchanged by introduction of high pressures and temperatures but exact application and control is now necessary. Research, accomplished and under way, brightens the road ahead and indicates solution of those problems not yet fully solved.

By C. H. FELLOWS

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Chairman, Joint Research Committee on Feedwater Studies.

Chairman, Chemists Subcommittee of the Prime Movers Committee, E.E.I.

DURING THE PAST DECADE the constant trend toward the use of higher operating temperatures and pressures in modern steam boilers has made necessary a more scientific treatment of boiler feedwater than has been practiced under operating conditions of lower temperature and pressure. This is due principally to the fact that the reactions between the constituents of the water as well as those between these and the boiler metal occur at a much greater rate at the higher temperatures and pressures. Furthermore, it is possible that reactions occur at the high temperature and pressure now being used that did not occur under the conditions of low temperature and pressure. For example, types of feedwater which caused little or no corrosion in boilers operated at low temperature and pressure, in many instances cause severe corrosion at high temperatures and pressures. Moreover, solubilities of impurities, particularly the scale forming salts in the boiler water, are altered by the high temperature encountered at high pressures, and whereas a given type of feedwater may not have caused scale to form in a low pressure boiler, the same type of water may cause harmful scale in a boiler operated at high pressure and temperature.

Similarly the carry-over of boiler water with the steam in the case of any particular type of water may be of greater magnitude under high temperature operation at high ratings than has been found to be the case under conditions of low temperature. This emphasizes the seriousness of carry-over and necessitates more rigid control to prevent burn outs in superheaters and power losses resulting from adherent deposits on turbine blades.

Fundamentally the basic problems with regard to feedwater conditions encountered in operation at both high and low temperatures and pressures are the same. In each case feedwater treatment is designed to prevent the formation of hard adherent scale, to eliminate corrosion, to inhibit the development of caustic embrittlement, and to prevent carry-over with the steam. The methods employed in feedwater treatment in each case differ principally with respect to the exactness of their application and control, and where relatively inefficient practices have provided adequate or satisfactory control of the boiler water problems under low temperature and pressure operation, refinements have had to be made in those practices as applied to higher temperature and pressure operation. In some instances the practice for low temperature feedwater control has had to be augmented by new processes to insure satisfactory steam generating conditions. This is exemplified in the use of chemicals to remove from the sphere of activity the relatively small traces of oxygen that escape the mechanical deaerating processes.

The extent of treatment for the prevention of adherent scale varies from little or no chemical treatment when evaporated make-up is used to the complete chemical treatment typified by the lime-soda softeners. In the modern high temperature, high pressure steam generating equipment all types are encountered. Boilers operating at 1200 to 1400 lb. per sq. in. gage are reported operating as satisfactorily using 100 per cent treated make-up as when using distilled feedwater and evaporated make-up. Except in those cases where silicates are encountered, or, where serious condenser leakage is likely to occur, the problem of the elimination of boiler scale is practically non-existent in the modern power plant. This is true because the damaging effects of scale under high temperature, high

er Problems Yield to Research

pressure operation are so thoroughly appreciated that in those cases where, of necessity, scale forming waters have had to be used, competent chemists or chemical engineers have recommended sound treating practice and maintained it under exact control.

There still remains much to be understood regarding the action of silicates in producing scale. This is true of low temperature and pressure operation as well as high. Fortunately, difficult controlled silicates are encountered in but few localities and they are receiving the attention of experts in this field.

Internal Treatment

In combating scale formation as the result of condenser leakage of a natural scale forming cooling water, internal treatment is used. For high temperature, high pressure operation the phosphate salts are generally found to provide adequate protection since they readily react with scale-forming salts to render them harmless in this respect, and themselves do not hydrolize as rapidly as the carbonate salts.

It has been in the field of internal treatment that the operator encounters the myriad of cure-alls for boiler water problems, yet the operators of the higher temperature installations are surprisingly free from offers of such compounds. Nevertheless there still remains in this field a variety of processes offered for internal treatment. It is not within the scope of this paper to discuss the merits of these. In complete justice to these, however, it should be noted that some are based upon sound principles and logical reasoning and have only to be proved in their efficacy to become accepted.

A significant development in this field of treatment for scale elimination is that, in the zeolite processes of external treatment, in which base exchange reagents have been found that give promise of yielding feedwater not only free of metallic ions but also free of the non-metallic ions. These materials, referred to as acid zeolites, are still in the experimental or development stage. Essentially they are resinous condensation products that exhibit properties of selective absorption and appear capable of being produced in several varieties and used in such combination as to remove nearly any objectionable ion from water. Their ultimate commercial development may be expected to materially aid in solving the problems arising due to the presence of ammonia or high concentrations of the carbonate ion in boiler feedwater.

Problems of the nature described in the preceding paragraph are primarily corrosion problems and it is with reactions that produce corrosion that the operators of high temperature and high pressure equipment are chiefly concerned. In the past, the emphasis has been placed on dissolved oxygen as the significant cause of corrosion. A clearer understanding of the fundamental reactions has indicated carbon dioxide, particularly when in solution, as an important factor. Thus if acid zeolites can ultimately be shown to be capable of aiding in the removal of this gas from the feedwater system, a material advance will be made in combating corrosion.

The problem of the effect of carbon dioxide appears to govern the ability to use otherwise pure distilled and untreated water in boilers. Many boilers have operated on distilled feedwater augmented with evaporated make-up at around 400 deg. F., but have found troublesome corrosion developing at higher temperatures. A very important aspect of higher temperature operation appears to be the necessity of artificially increasing the pH value of distilled water when the temperature of operation is much in excess of 400 deg. F. This is accomplished by the use of only a small amount of sodium hydroxide, sufficient to maintain a pH value between 10.5 and 11.0.

Corrosion under high temperature operation becomes not only a problem of the reactions of the constituents of water upon boiler metal, but one of pure water itself upon the metal. This has led to much attention being paid the type of metal used in the fabrication of boilers and includes not only drums and tubes, but steam lines, economizers, and superheaters. The selection of proper boiler metal for high temperature service is based upon very meager information at the present time. There is little exact data on the reaction of steam and water with metals at elevated temperatures, yet indications of the magnitude of such reactions have been pointed out in this country and abroad. Such experimental work as has been carried out has indicated rates of corrosion between what may be classed as serious attack of low carbon steel at 1000 deg. F. and a negligible reaction at that temperature between steam and certain chromium nickel alloys.

Metal Reactions

There is under way at present a significant investigation at Purdue University designed to throw light upon the exact magnitude of the reaction between steam and metal at elevated temperatures. The work is being sponsored by the A.S.M.E. and by both manufacturers and users of boilers. Between 15 and 20 alloy steels are to be studied in this program. The temperatures and pressures in the tests will range from 800 to 1200 deg. F. and from 400 to 2300 lb. per sq. in. gage respectively.

The reaction encountered, especially in the case of low carbon steel, is one in which the water is reduced, liberating hydrogen and the iron becomes oxidized to ferrosic oxide (black magnetic iron oxide, Fe_3O_4). Indications of the occurrence of this reaction in superheaters delivering steam between 800 and 900 deg. F. have been observed in some of the newer installations.

On the basis of the present knowledge of this re-

action it would appear that feedwater treatment has no part in its elimination or control. On the other hand feedwater treatment has been used effectively in augmenting the work of deaerators in removing dissolved oxygen. Sodium sulphite has been used generally and with apparent success at operating pressures in the neighborhood of 400 to 600 lb. per sq. in. gage. The reactions of this salt under boiler operating conditions are not clearly understood and important research in this connection is under way at the University of Illinois. Colloidal iron and ferrous salts have also been used for this purpose and successful operations at 1200 lb. per sq. in. gage pressure have been reported.

Caustic Embrittlement

The work of Professor Straub and his associates at the University of Illinois led to an apparent rational explanation of the mechanism of embrittlement as well as of inhibitive measures for its prevention. The explanations of the prevention of embrittlement growing out of this work and the experiences of the industry pointed to the deposition of solid sodium sulphate in the form of a protective scale which prevented the direct contact of sodium hydroxide in solution with the metal.

Perhaps the most common economic error made in treating or conditioning water for steam generating purposes is that of over-treatment. The possibilities of over-treating boiler waters became recognized as operators attempted to maintain the suggested A.S.M.E ratios designed to inhibit the development of caustic embrittlement. The apparent necessity for increasing the sulphate ion concentration of boiler waters in an effort to counteract the influence of sodium hydroxide almost invariably led to the accumulation of an abnormally high concentration of dissolved salt in the water.

It became apparent that if the deposition of solid sodium sulphate was actually the primary factor controlling development of caustic embrittlement, a more systematic boiler water treatment might result from the application of exact knowledge regarding the solubility of sodium sulphate in boiler water containing various concentrations of sodium hydroxide. The primary objective of the work of the Joint Research Committee on Boiler Feedwater Studies, as directed by its Subcommittee 6, and carried out initially by Drs. E. P. Partridge and W. C. Schroeder, was to determine the solubility of this salt, sodium sulphate, at various temperatures and pressures in that concentration of sodium hydroxide established as necessary to produce caustic embrittlement. The work of Professor Straub and his associates had indicated that caustic embrittlement did not occur in water containing only sodium hydroxide in concentrations less than 100 grams per liter, that is, 100,000 p.p.m. and the experiments of the Joint Research Committee, designed to induce failure in specimens involved both tension and torsional tests using concentrations of sodium hydroxide of this order. In carrying out these tests, facts were developed that indicated that the current understanding of the mechanism of the development of caustic embrittlement might be incorrect.

Although a few exploratory tests of the Joint Research Committee investigations had indicated that the minimum concentration of sodium hydroxide necessary to cause boiler metal cracking might be somewhat lower than that found by Professor Straub, the determination of the exact concentration was held in abeyance until the completion of certain other studies then under way. These studies involved the determination of the solubility of sodium sulphate in boiler waters containing concentrations of sodium hydroxide from 0 to 200 g. per liter and various concentrations of other salts, such as sodium chloride, sodium carbonate and sodium phosphate as were to be normally found in typical boiler waters. This objective has been fulfilled and reports made public in the meetings of national engineering societies, as well as through the technical press, have indicated that other salts might be expected to precipitate from these concentrated boiler water solutions which upon further investigation may be proved to be as effective in combating this situation of caustic embrittlement as sodium sulphate has been.

As a result of this work two findings, very significant in the correct conditioning of boiler feedwater, have been brought to light. The first of these relates to the theoretically correct proportioning of the sodium sulphate concentration to that of sodium hydroxide, which, when the present research program permits complete evaluations of all factors, should enable the operators of steam generating boilers to treat more exactly than they might by strictly following the suggested A.S.M.E. ratios. The second concerns the possibility that inhibitive treatment might be reasonably carried on with the maintenance of certain relative concentrations of salts other than sodium sulphate. The Joint Research Committee has not taken the attitude that these two findings are conclusive but rather has looked upon them as an indication of the necessity of further research work to definitely establish the true mechanism of the development of this phenomenon. It has considered that the application of the A.S.M.E. ratios has in most cases effectively prevented the development of caustic embrittlement and that until more exact information regarding its mechanism has been established, no major changes in inhibitive treatment should be made.

These considerations led the officers of the Joint Research Committee and the members of Subcommittee 6 to extend their research program to include investigations that held reasonable promise of establishing the fundamental facts and reactions that controlled the development of embrittlement.

Research Extended

The extended program of research involving this subject of caustic embrittlement has grown out of two findings principally, that were disclosed during the earlier studies. The first of these was that pure sodium hydroxide in distilled water did not appear to produce caustic embrittlement but that this phenomenon appeared in the laboratory test specimens only when other salts were present as impurities in the caustic solution. Jointly with Professor Straub, it was established that soluble silicates at low concentrations influenced the development of caustic embrittlement in caustic solutions perhaps more than any other salt. This finding is of considerable importance in the un-

derstanding of the true mechanism of caustic embrittlement and a part of the extended research work is planned to determine not only the part that silicates play in this reaction, but also the exact effect of several other salts. The second finding which has served to point the way in this further study was that when specimens stressed in torsion were subjected to the influence of embrittling solutions, sodium sulphate in solution or in solid form failed to inhibit the development of cracking.

This finding has led to the consideration that effective means of prevention must lie, not in the realm of deposited scales which are subject to cracking under reverse stresses, but possibly to the formation of molecularly thin films on the metal surface. This consideration has been emphasized by the finding that several well known oxidizing reagents appear to be as effective as solid sodium sulphate in the inhibition of caustic embrittlement when produced in specimens under straight tension. This finding also offers a possible explanation for the experiences of the railroad companies who have consistently maintained that typical embrittlement cracking in their equipment could not be prevented by the maintenance of the suggested A.S.M.E. ratios which involve sodium sulphate as the inhibitive reagent.

The investigation is not being confined entirely to the results of laboratory tests in which steel specimens are considered to crack or not crack under specific chemical and physical conditions but consideration is being given the study of oxide on the affected metal surface, by optical and electron diffraction methods. The experimental work likewise is not being limited to static stresses but includes testing involving reverse stresses and torsional stresses.

The problem of carry-over at the higher operating temperatures and pressures has not been indicated as being more significant than at the lower temperatures and pressures. Considerable interest among power plant operators and turbine manufacturers is being manifest, however, as evidenced by a current coöperative effort among power plant engineers to collect operating data bearing on this problem. The primary interest in carry-over is the result of its occurence. Salts in solution or suspension in boiler water may deposit in superheater tubes where serious tube failures may occur, or as an adherent scale on the turbine blades and steam nozzles.

Professor Straub at the University of Illinois has reported significant results of an investigation of the cause of and method of eliminating adherent blade deposits through the maintenance of certain relative sodium sulphate concentrations.

The work on foaming and priming under the direction of Professor Foulk at Ohio State University has contributed much to the general understanding of the causes of carry-over. Significant among the findings disclosed in that research are the following: One, at higher pressures the tendency toward foaming is less than at lower pressures. Stated in another way, increases of pressure by as little as fifty pounds per square inch gage in the case of a foaming water will serve to stop the foaming, and before it can reoccur at the higher pressure the concentration of the salts in the water has to be increased. Two, foaming values for the various salts encountered in boiler water have been established for the laboratory conditions under which the tests were made, and it has been found that these values are additive. Three, the tendency on the part of suspended matter to produce foaming is dependent upon the physical state in which it exists.[1]

For example magnesium hydroxide in a state of finely divided crystals or in an amorphous state has been found to produce foaming, whereas the same precipitate in larger crystal size appears to reduce the foaming tendency. Again, in the case of certain salts, precipitation inside the boiler has been found to decrease foaming probably because of the formation of larger crystals, whereas precipitation outside with subsequent introduction into the boiler water increased the tendency of the water to foam.

Steam washers and baffles are being used successfully as mechanical methods of eliminating carry-over.

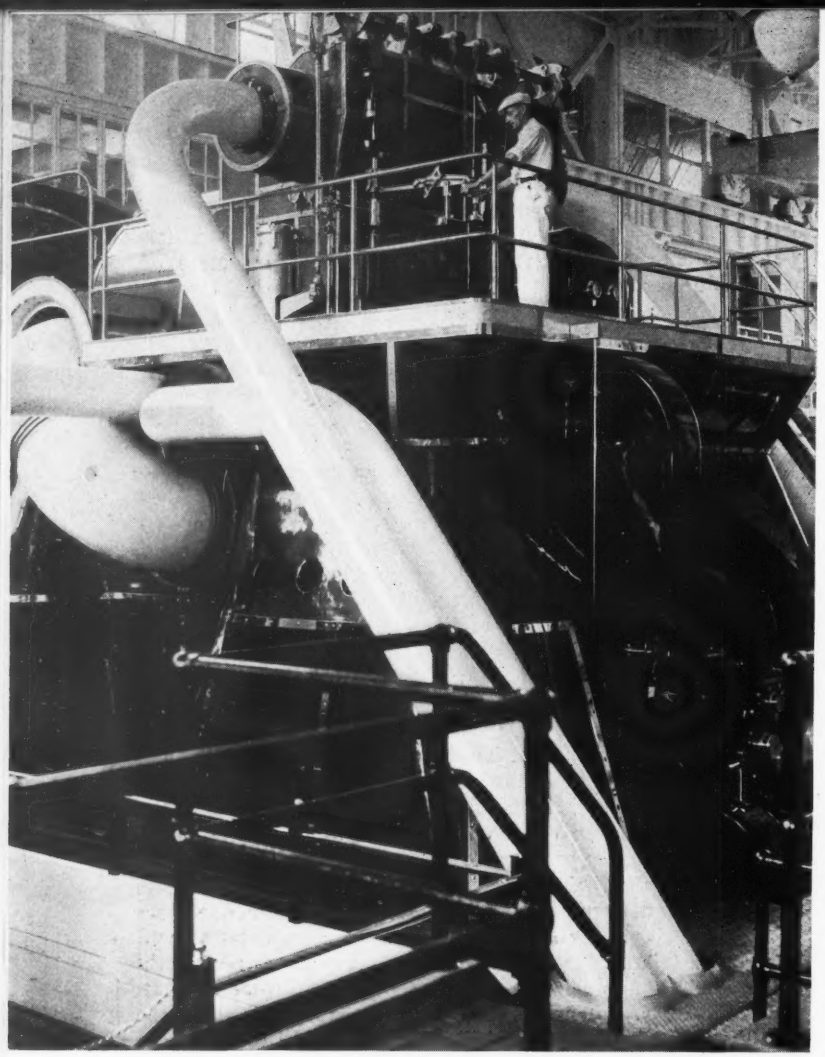
One of the most important developments in the past ten years in this problem of boiler feedwater treatment is the growing realization of the necessity of exact methods of analysis of water. During this period many investigators, as well as the Joint Research Committee on Boiler Feedwater Studies, the A.S.T.M. and the American Public Health Association, have contributed descriptions of important test methods to the general fund of knowledge. Particularly significant among these is the method for the determination of the concentration of dissolved oxygen. The necessity of knowing the presence of this gas even though dissolved in the feedwater in exceedingly low concentrations has been demonstrated many times, and where operators set absolutely none as the maximum amount that will be tolerated, the importance of very exact test methods is appreciated.

A recent development in this particular field is the dissolved oxygen recorder which enables a continuous record of the concentration of this gas in feedwater to be made.

Conclusion

In concluding this review it may be noted that on the basis of present day experience there would appear to be less fundamental differences in the rules governing correct boiler water treatment for high pressure and low pressure boilers respectively than was at first expected. The importance of correct treatment becomes greater as the pressure increases, primarily because of the severity of the damage that may result from faulty treatment. In those instances on record, treatment of the water in high pressure boilers has been to maintain a pH value of 11 or more with adequate treatment to prevent scale deposition and the development of caustic embrittlement. Where deaeration has not removed all dissolved oxygen auxiliary chemical treatment has been used. Where carry-over has been experienced with high-pressure equipment, adequate correction has resulted from the use of steam baffles or screens as in the case of low pressure operation. Available data do not make it possible to set generally applicable limits for maximum concentration of boiler water salts under high pressure operation. Continued observation and correlation of operating data are necessary before definite rules relating to treatment and operation can be made.

[1]Private communication.



TURBINES

Turbines and engines, in sizes from a few to 75,000 kw., compete in rush to add a million kilowatts to the nation's generating capacity.

The new 110,000 kw., 1215 lb., 900 deg. F. turbine in Ford's River Rouge plant is the largest high temperature unit yet built

BACK OF THE EVER incessant demand for cheaper power, the engineer must carefully balance first cost against heat economy. It is probable that the heat economy record of Port Washington will stand for some time and that the plant of the immediate future, neglecting top plants whose performance is more or less fixed by existing equipment, will be in the 12,500—15,000 B.t.u. class with ultimate power economy resulting from lower fixed charges on simplified plants in the 600—800 lb. pressure range.

This hardly seems consistent with the trend toward hydrogen cooling of large generators which results in improving the generator efficiency a relatively small amount from 0.6 to 1.1 per cent. It must be remembered, however, that this increase in efficiency is measured in terms of power delivered at the coupling, and due to the turbine efficiency, represents approximately three times the value in terms of turbine heat rate. The real importance of hydrogen cooling, however, is the part it plays in making economical the production of large 3600 r.p.m. units.

This increase in size of high speed units is perhaps the most important turbine trend of the year, the largest 3600 r.p.m. units announced to date being the two 60,000 kw., 1200 lb., 925 deg. F. machines for Windsor Station.

In this same class comes the 50,000 kw. Waterside turbine shown by Fig. 2. More important than the physical size of this unit is the arrangement of the turbine or turbines to take care of the feedwater heater requirements for plants so old that extraction was not provided for. The unit is in effect two turbines arranged on the same shaft, the main turbine taking steam at 1200 lb., 900 deg. F. and exhausting at 200 lb. The second or feedheating turbine will take steam at 200 lb., with intermediate extraction and exhausting at 15 lb. to the open heater, the steam flow through the unit being determined by the feedwater heater requirements.

Both of these high speed units are, of course, for non-condensing operation, but new records have also been set by the 25,000 kw., 3600 r.p.m., 640 lb., 825 deg. F. single cylinder condensing unit for Montville Station. This more than doubles the present record for 3600 r.p.m. single cylinder units and is a considerable advance over two cylinder tandem construction. It is expected that the two cylinder record for machines of this speed will soon, however, be boosted as high as 40,000 kw.

For the first time in many years plant construction trends seem to be such that some degree of standardization in turbine design may be expected with a corre-

S Meet the Prosperity Wave

sponding reduction in costs. At present, there seems to be a trend toward moderate size units, the 75,000 kw. turbine for Cahokia being the largest to date if the 150,000 kw. unit for State Line are neglected. The extension for State Line was started several years ago and the turbines ordered at that time so that it can hardly be considered in relation to present trends. The State Line pressure has been raised from the 800 lb. in the original section to 1200 lb. The Cahokia unit is an extension and conforms to past pressure and temperature of 315 lb. and 725 deg. F.

Present turbine practice is limited to 900 to 950 deg. F. by metal characteristics while the pressure is limited to a maximum of about 1200 lb., oddly enough by the allowable moisture in the turbine exhaust. A maximum of about 12 per cent is now considered practical by turbine manufacturers without excessive erosion in the low pressure blading. The River Rouge plant goes the limit in this connection and the expansion line of the turbines is as far to the left on the Mollier Diagram as is now considered practical.

New types of construction and advances involve many problems and the results thus far accomplished would have been impossible without the great amount of research and special development work carried out by design engineers and metallurgists. Of these problems, those surrounding the advance in inlet steam temperature are the most difficult and of greatest significance.

Creep

In turbine construction, the clearances between stationary and rotating parts are necessarily relatively small, and the creep of metals, that is, the rate of change of deformation, is of such value at the temperatures now encountered that it becomes a major factor in design. It is no longer merely a matter of designing parts to prevent failure, but they must be proportioned to insure the maintenance of dimensions within the desired limits, under the influence of creep, throughout the life of the machine.

Accurate data on the creep characteristics of metals has not been available in the past and cannot be obtained except by long time tests. The subject has received a great amount of study and not until quite recently have sufficient data been available from which reliable conclusions can be reached.

Temperature Effect

Some of the most outstanding facts determined by these studies which may give a better understanding of the problems confronting the design engineers are summarized (by E. R. Kauffman of Westinghouse) as follows: First, a characteristic feature of most available materials for temperatures below 1000 deg. F. is that the creep progresses very rapidly at first and then more slowly. From this it is concluded that the material changes its properties in a fundamental manner with the passage of time and a test result can be considered reliable only for the time range actually covered by the test. Second, as the stress is increased by arithmetical increments, the creep for any given time and temperature is increased by geometrical increments. For example, at 850 deg. F. an increase in stress of 2500 lb. per sq. in. will, for any given time, approximately double the creep in 0.35 carbon cast steel. The corresponding figure for cast carbon molybdenum steel and forged 13 per cent chromium steel is approximately 5400 lb. per sq. in. Third, as the temperature is increased by arithmetical increments, the creep for any given time and stress is increased by geometrical increments. For example, in the high temperature regions, an increase of 12 deg. F. for any given time and stress will approximately double the creep in 0.35 carbon cast steel. The corresponding figures for cast carbon molybdenum steel and low car-

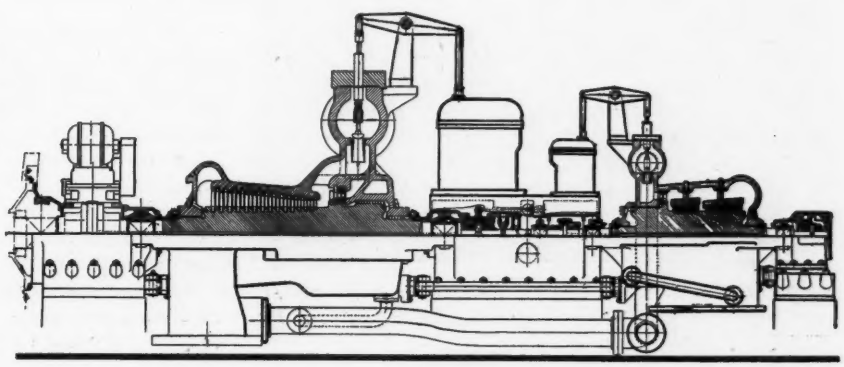


Fig. 1. Longitudinal section of the 50,000 kw., 1200 lb., 900 deg. F. Waterside turbine which incorporates a low pressure feedheating turbine on the main shaft

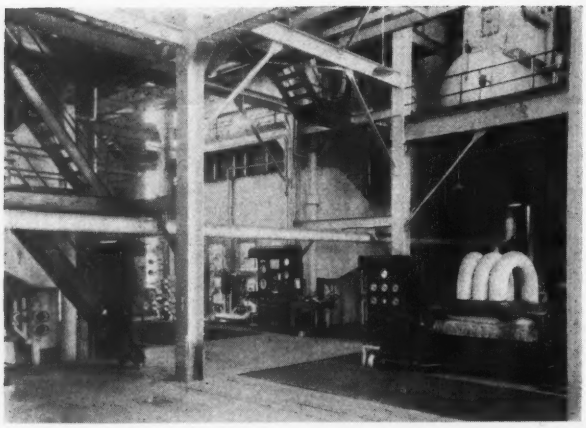


Fig. 2. At Mound Street Station, the turbine is installed adjacent to the boilers, a common practice in top plants

bon chromium steel are 22 and 48 deg. F. respectively. This influence of temperature is known with much less exactness than that of stress.

From the above it can be seen that the influence of temperature, especially in the region of 900 to 1000 deg. F. is of utmost significance and any further advances must be considered seriously. For this reason, the cylinders for the high temperature turbines now under construction are made of carbon molybdenum steel.

Turbine Orders

During the first 10 mo. of last year, the central station industry purchased a total of 19 units of 7500 kw. or over, eight of them being for superimposed plants. The total capacity was over 600,000 kw. and this, together with more recent orders and industrial units should bring the total capacity ordered during the year to well over 1,000,000 kw.

Industrial plants have been just as active as central stations and the list of new plants has been increasing so rapidly that it has been impossible to keep it up to date. Inasmuch as the greatest field for the industrial plant is in non-condensing operation and superimposed units, the initial pressure and temperatures of industrial plants generally fall below those of the central station due to the necessary lower pressures and temperatures required of the turbine exhaust. In general, industrial requirements fall in below the 650 lb., 750 deg. F. range, although the River Rouge and Pittsburgh Plate Glass installations are exceptions.

In the latter plant the new turbine takes steam at a maximum of 850 lb. 825 deg. F., although normal throttle conditions are but 825 lb., 750 deg. F. Automatic extraction is provided at 400 lb. pressure and the turbine exhausts at 140 lb. to the low pressure steam system supplied by old boilers. Figure 3 is a photograph of this unit installed.

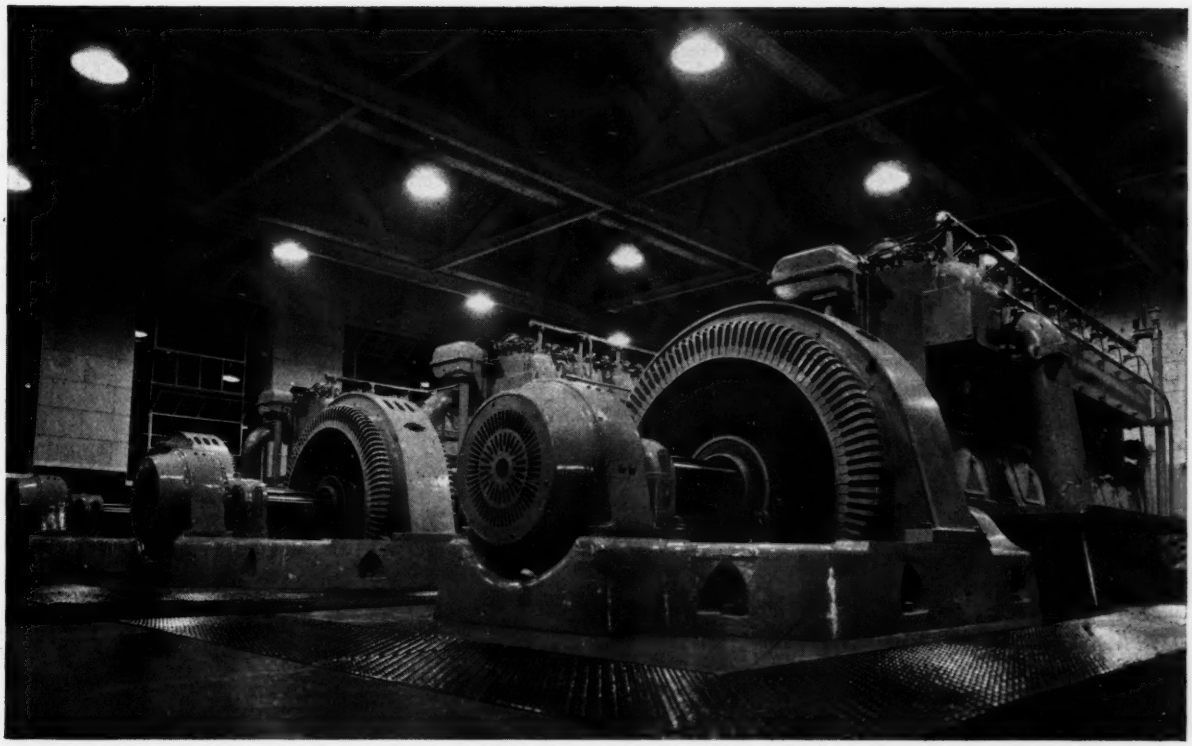
Fig. 3. This 5000 kw., 850 lb., 825 deg. F. turbine at the Barberton, O., plant of the Pittsburgh Plate Glass Co. bleeds at 400 lb. pressure and exhausts to a low pressure steam system at 140 lb. (Photo, Westinghouse Elec. & Mfg. Co.)

Fig. 4. Steam engine drive is still popular for auxiliaries and for driving process equipment. The units above are driving milk dryers in the Ward Dry Milk Co. plant (Photo, Troy-Engberg Engine Co.)

Operating at but slightly lower pressure, the 600 lb. Postum turbine is also an excellent example of an industrial plant unit normally exhausting at back pressure but with automatic provision for partial condensation of the exhaust under normal conditions. The Chevrolet Forge unit, with the same initial pressure but designed for different process requirements, is provided with a conventional condenser but provided for automatic extraction at 140 lb. for steam hammer and compressor operation.

Due to the prevalence of top plants the condenser has had small chance of shedding its depression garb, but the recent announcement of several condensing plants should bring important developments during the coming year. Bleed heater practice has been reasonably well standardized, and although detailed changes are being made on the high pressure units, these changes are not fundamental.

Steam engines long the standby for service institutions and small plants where efficiency is of prime consideration remain fundamentally unchanged, but have been improved greatly in detail. The Van Brunt Mfg. Co. plant, just completed last summer, is a good example of the modern engine plant. The high efficiency of the very small steam engine makes it advantageous for driving process equipment, which also uses the exhaust steam. Such an installation is shown by Fig. 4, the steam piping for the engine working in very nicely with the piping for the dryers.



Photo, The Winton Engine Co.

THE DIESEL DISCOVERED

Forty years after Adolphus Busch introduced the Diesel to America the newspapers and public rediscover it as a railroad achievement. Development really started during the World War and it is estimated well over 2,000,000 hp. were manufactured in this country during 1936

DURING THE DEPRESSION Diesels gained a firm seat in the saddle and may now be considered as accepted standard equipment for the smaller municipal plant and highly competitive equipment in the larger plants. This is not due to new developments as much as to a long and strenuous uphill fight to gain well merited recognition. In the foremost ranks of the pioneers are a number of prominent plants that have just added, or have announced additions of large size units. Among these are Rockville Center, N. Y., a 3865 hp. unit; Carthage, Mo., a 2250 hp. unit; Grand Haven, Mich., a 2250 hp. unit; Freeport, N. Y., a 3000 hp. unit.

These few of the larger units, all put in stations with years of experience behind them, prove definitely the permanent position the Diesel now occupies. Equally important is the large number of smaller plants completed or under way. Due to the unusual activity a list of such plants would be premature at this time, but among them may be mentioned Corning, Ia., with 700 hp. in three units; Cushing, Okla., with three 750 hp. units, and Tipton, Ind., with three 750 hp. units. This latter plant is shown by the headpiece and is of unusual interest because it shows what can be done to modernize an old building. The interior was refinished with acoustical material to give a modern appearance and deaden noise. Peaks run 900 kw. in the daytime and 400 kw. at night, leaving one unit for a spare at all times.

More important perhaps because of the great opportunity for higher overall efficiency is the rapidly growing number of plants combining Diesels and steam electric generation with process or heating requirements. Windom, Minn., is using two 375 hp. units in this way. During the winter season the load will be carried primarily by the steam units exhausting into the steam heating system. During the summer, when the steam load is high, the power load will be carried principally by the Diesels.

At Arcade, N. Y., a recent installation of 800 hp. in 2 units is used in the same way, the sale of steam ranging from 12 to 16 million pounds per heating season at the exceptionally low rate of 60 cents per thousand pounds. Hotels, stores, office buildings and

industrial plants have unlimited possibilities in this connection. Macy's Department Store, the Singer Building and the Hotel New Yorker, all in New York City, are excellent examples of this practice. The Hotel New Yorker plant has this year been extended by the installation of a 750 hp. unit.

Automatic Operation

In New England an industrial plant has just completed a combination steam-Diesel installation, noteworthy for two reasons: automatic operation and the use of high speed Diesels. The same method of automatic control has been in use for some time on similar engine units at the North Easton Pumping Station and an all Diesel installation is now in operation at another New England industrial plant.

The Maclan Hat Corp. have installed a balanced steam and Diesel electric power plant consisting of a 300 r.p.m., 550 v. 3 ph., 60 cycle, 200 kw. Corliss engine driven generator operating at 125 lb. boiler pressure and 15 lb. exhaust pressure; and a double-ended 100 kw., 1200 r.p.m., 550 v., 3 ph., 60 cycle generator driven by two 80 hp. Diesel engines through over-running clutch couplings. The two generators are arranged for parallel operation, with the Diesel driven generator floating on the line as a synchronous motor when the Diesel engines are not operating.

H. Schindler & Co., Inc., has installed a 50 kw. automatic Diesel electric generating plant consisting of a double-ended 1200 r.p.m., 220 v., 3 ph., 60 cycle generator driven by two 40 hp. Diesel engines. The control is arranged so that one engine runs continuously with the second engine cutting in and out automatically on an increase or decrease in the load above or below the capacity of the continuous running engine. The automatic control is actuated by the exhaust temperature of the continuous running engine, which is an exact indication of the load.

Another, and extremely important application of the Diesel for industrial plants, is the installation of small units, arranged for automatic starting to carry emergency loads in case of power failure. The Pittsburgh Plate Glass Co. has one such installation at Mt. Vernon, O., and is now completing a second installation in West Virginia.

High Speed

The high speed, small capacity Diesel is one of the major products of the depression. A number of these small units are now on the market and a number of installations have been made. As a full background of experience is lacking, there is still some doubt as to the maintenance expense and life of these units under continuous load operation. That the Diesel industry itself feels future prospects very good indeed is shown by the large number of manufacturers now offering or developing high speed units.

To what extent these engines may play in special applications depends to a large extent on satisfactory control equipment and its proper functioning so that the small multiple units can operate at high load factor. The new large streamlined Burlington trains have several small auxiliary engine generator sets with newly developed automatic synchronizing equipment.

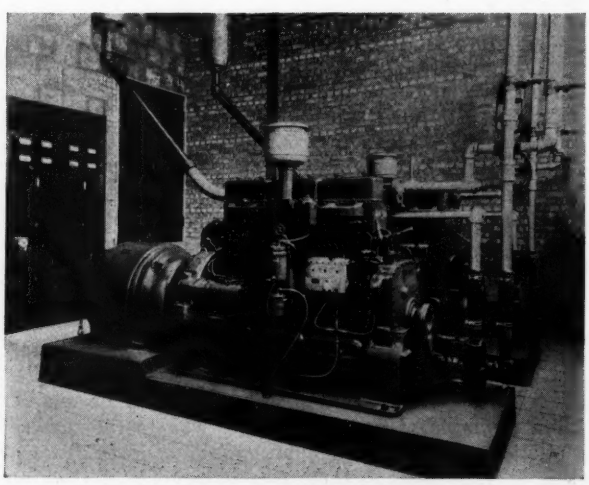
Railroad needs are of course far different from those of stationary plants due to limited space and weight, but of recent years the railroads have furnished the highlights. The range and diversity is constantly being increased, the largest locomotive engine now in service being the 2000 hp. freight unit on the Illinois Central System. This is a 10 cyl. V-type engine with a maximum speed of 5550 r.p.m.

Perhaps the most significant development of the year, however, is the reported purchase of five switching locomotives by the Birmingham & Southern Railroad. These units will be powered by 900 hp. supercharged engines. Without supercharging these engines would be rated at but 600 hp. Supercharging has been in use in Europe for some time, but in spite of theoretical advantages this is apparently the first serious attempt to introduce it into this country.

Another phase of Diesel activity that has met with little practical application outside of Germany has been the aviation Diesel. Last summer the Trans-Atlantic flight of two German planes powered by Junkers Diesels demonstrated conclusively what Germany has accomplished along this line. The Hindenberg, maintaining a definite schedule between this country and Germany, also depends upon Diesels, four 1200 hp., at 1600 r.p.m., V-type units, with a cruising speed of 800-900 r.p.m. German experience in this line goes back 20 yr. and many of the commercial planes are Diesel powered. It is questionable if the weight will ever be reduced as low as for gasoline engines, but several present designs have reached a figure of or around two pounds per horsepower.

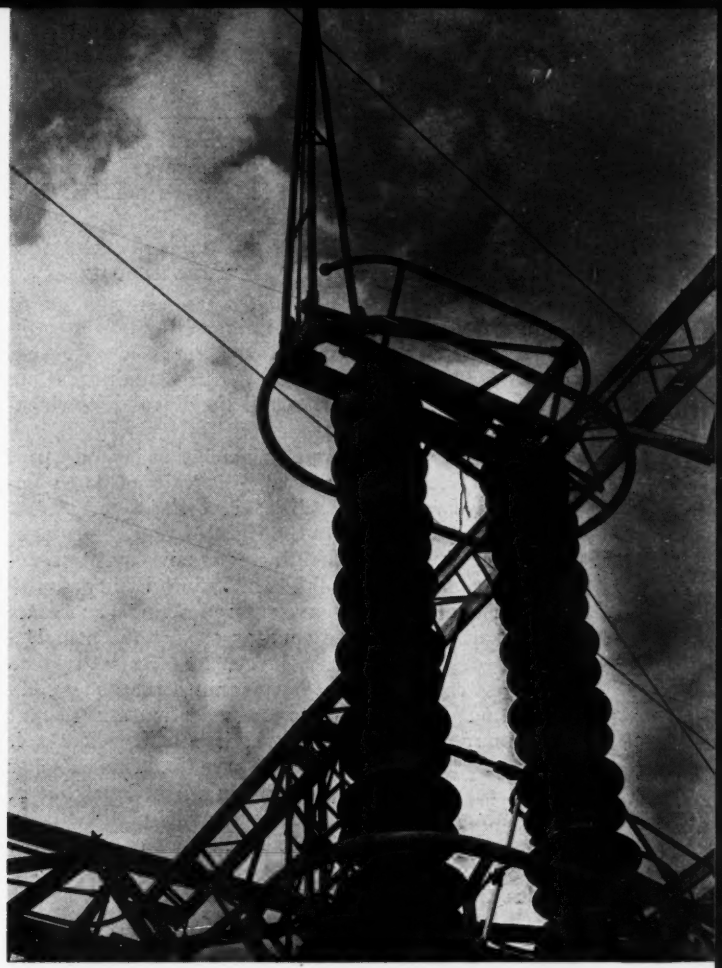
In addition to many new engine models and designs which will be taken up in detail later in the year, progress is reported on the crankless Diesel first announced a year or so ago and trial marine installations are reported as now under way using 620 cu. in. displacement engines developing 150 hp. at 1200 r.p.m.

Another line of internal combustion engine development that seems to be forging to the front is the use of waste gas from sewage plants in internal combustion engines. Further details of this practice are given in the article on fuels.



Two 75 kw. Diesel sets in the Vail Mfg. Co. plant in Chicago. Small high speed units of this type are becoming of increased importance to the smaller type of industrial plant (Photo, The Buda Co.)

Modern Power Equipment in Geometric Form. A 287,500 v. disconnecting switch installed at Boulder Dam



Photo, Bureau Reclamation.

From Faraday to T.V.A.

Highlights of the Year's Activities in the Electric Light and Power Industry.

IN PRESENTING a review of the advances and the developments in the field of electrical engineering during the year, we find it difficult to decide upon the limits of our discussion. Electrical Engineering is a term so broad, so vast in its scope that were we to consider it as a whole, our discussion would extend into every field of human endeavor and into all aspects of civilized human life. At the outset, therefore, it becomes necessary for us to restrict our discussion as much as possible to those advances in the field of electrical engineering which are more or less directly related to the generation and distribution of electric power. Even with this restriction, however, in the articles which follow it will be necessary at times to deviate from the strictly power field in order to discuss developments which though they lie outside of the field proper nevertheless are related to it.

Fundamentally, of course, the electric power industry has its roots in "physics," in fact, as Dr. Joseph Slepian pointed out recently in an address before the American Institute of Physics,[1] "the electric power industry was born in the laboratory and in the mind of the pure physicist, Michael Faraday, and its activity may be described as repeatedly and continuously in large scale and in small, and in the most varied manners, giving demonstrations of his law of electromagnetic induction. Magnetic field in iron links electric current in coil, in generator, motor and solenoid in endless profusion upon this earth. Great dams are built and momentous political issues arise in connection with further repetitions of Faraday's great experiment."

Slepian's reference to political issues is of particular significance here because the political aspects of the power industry have engaged more than usual attention this last year. In a brief review, such as this, it is not expedient to enter into a detailed discussion of the political aspects of the power problem nor is it desirable, but a brief summary of the more important points will not be out of place. To many this entrance of power into the limelight of national and local politics is distasteful and they regard it as a degradation of the art. They contend that electric power is not a God-given right or a natural resource, that it is purely a man-made service, subject to economic laws and that it has no place in politics. This point is debatable and need not be discussed here, the fact remains that power has become of great importance to a large number of people and therefore has acquired a social significance far beyond that which it had in the years of its early growth. Power is becoming to be recognized as a social agency much as are roads and highways, waterworks and sanitary systems, a commodity to which people are entitled because of the age in which they live—not free but at a cost within reach of all. Regardless, therefore,

[1]Some Physical Problems in the Electrical Power Industry, presented before a symposium on the subject, Physics in Industry, Oct. 28-29, 1936.

of individual opinions it is inevitable that power will become of increasing social significance and from this standpoint its prominence in last year's political field is readily understandable.

Political Aspects of Electrical Industry

In general the political activity of the power problem last year was centered in four main issues: Holding Company legislation; Public Works Administration, Tennessee Valley Authority and the Rural Electrification Administration.

As far as holding company legislation is concerned, the activity last year consisted largely of legal encounters between the Utilities and the Government. The Utilities, who dispute the right of the Government to limit the existence of holding companies and to regulate such companies, contend the Public Utility Act to be unconstitutional and have entered a number of cases in different parts of the country to test the constitutionality of the act. The Government has sought to have these cases held in abeyance until the issue could be tried out in a case of its own selection and to that end was reasonably successful; it commenced a suit against the Electric Bond and Share Co. This case has progressed steadily toward the Supreme Court but at this writing the final outcome cannot be predicted. In the meantime a majority of the utility companies in the country have declined to register with the Federal Securities and Exchange Commission as required by the act. Objections involved also include the uniform system of accounting devised by the S.E.C.

The political elements involved in the P.W.A. and T.V.A. are too well known to require any more than a brief mention here. Fundamentally, the Utilities object to both of these agencies in their present form at least upon the grounds that they impose unfair competition upon the Utilities in the generation, distribution and sale of power and in encouraging such competition by the extensions of loans to municipalities. Furthermore, aside from the immediate issues involved there is always the fear of the Utilities that the entrance of the Federal Government into the power business ultimately will lead to a nationalization of all power generating and distribution facilities. Here again, the year's activities involved numerous suits and restraining injunctions against the Government. These suits have, for the greater part, been local affairs and have been marked by victories on both sides.

In the case of T.V.A., however, the case reached the Supreme Court and the decision rendered in February was in favor of the Government, but it was restricted to the specific case between the T.V.A. and Alabama Power Co. involving the Wilson Dam (Muscle Shoals) development. In this decision, the court upheld the federal generation, transmission and wholesale power disposal along rather broad lines but at the same time the court pointed out that the ruling did not include other T.V.A. dams nor did it involve the constitutionality of the T.V.A. itself. Thus both sides found comfort in the decision but the fight remains in progress. The whole T.V.A. area bristles with suits and injunctions. In the meantime construction of the various T.V.A. and P.W.A. projects continue and with the reelection of President Roosevelt their completion is practically assured.

Regional Power Pools

An element of considerable interest is the proposed formation of regional power interchange pools and the plan for close cooperation between the federal and state utility commissions. This by some is regarded as an indication that the Federal Power Commission is losing no time in enforcing the provision of the Federal Power Act incorporated in Title II of the Public Utility Act of 1935. Five regional offices have been established in Denver, New York, Atlanta, San Francisco and Chicago. Under the Federal Power Act, the Federal Power Commission has the authority to order private untilities to interconnect their transmission lines with those of other systems, private or publically owned, and this may be the beginning of a comprehensive plan for integrating and coordinating the transmission and power resources of the country on a national scale. It is to be expected that private utilities will oppose any attempt on the part of the Government to convert their transmission lines into common carriers for current generated at federal plants, especially when the current is to be transmitted to municipal distribution systems financed by federal loans and grants.

Rural Electrification Shows Great Activity

Perhaps the most significant trend in the electric power industry during the past year has been the remarkable activity in the field of rural electrification, both through the Rural Electrification Administration and by private utilities. The R.E.A. was set up in 1935 to establish and administer a program of projects for the generation and distribution of electrical energy in rural areas with Morris L. Cooke as its director. In May, 1936, President Roosevelt signed the bill appropriating $410,000,000 over a period of 10 years to be used in electrifying approximately one million farms now without electric service. During the year many loans were made to coöperatives in various parts of the country for the construction of rural lines under the provisions of the act. Loans are also available to private power companies under this act but only few such loans were called for. This activity by the government has greatly stimulated rural line construction by the private utilities, indeed rural construction broke all previous records during the year. At this writing final figures are not available but the number of miles of rural lines built in 1936 is expected to be almost double the number constructed in 1935. Nearly 100,000 rural customers are expected to take current from the new lines and close to 60,000 new rural customers will be added to existing lines. R.E.A. allotments for the year totaled about $50,000,000.

So much for the political side of the electric power industry. While there is considerable bitterness on both sides, progress is being made in many directions. As in all instances of this nature in the processes of adjustment and readjustment, mistakes will be made and injustices committed, but gradually there will emerge a better understanding of the whole situation. Electric power is entirely too important an element in the modern world to be ignored and it will remain in the political and social picture for a long time to come. It is too vital a force in our national life to be controlled or limited in its application in the interests of a minority.

Outlook for the Utilities Hopeful

While there is still concern and apprehension on the part of the Utilities in regard to the practices and policies of the administration, there is, at the same time, a much more hopeful outlook. And for good reason. With the power load higher than it has ever been before and still increasing, with better business conditions throughout the country the outlook is very hopeful. The record of business in the electrical industry for 1936 is truly astonishing. Almost without exception the earning reports of the manufacturing companies and operating companies show notable advances.

The result of the national election had no noticeable effect whatever upon the outlook for the electrical industry, except perhaps that it removed certain mental hazards in the minds of utility executives and engineers. The general feeling after the election was over was to forget politics, to keep busy and out of conflicts. Long range construction programs it was pointed out must of necessity be plotted against output curves independently of elections or political developments. The nine months roundup of Business Week early in November showed increases as follows for 1936 over 1935: Residential construction up 74 per cent; non-residential up 74 per cent; public works and utilities up 67 per cent; factory employment up 6 per cent; factory payrolls up 14 per cent; farm income up 14 per cent. With these remarkable increases in general business activity and with the national income up to 60 billion dollars, it is inevitable that the outlook for the electrical industry should be exceedingly hopeful.

The steadily increasing central station load, as predicted by the Federal Power Survey of 1935, makes necessary considerable additional generating capacity, and many new installations were started. Most of these were of the so-called "top" type wherein a high pressure turbo-generator is superposed on the existing system. Among the largest of these "top" units is that being installed at Waterside Station of the New York Edison Co. The modernization program at this plant, which is one of the older stations of the New York Edison System, calls for the retirement of 36 of the old boilers in the station and 3 of the old turbo-generators and for the installation of two new boilers each of 500,000 lb. per hr. capacity and one new 50,000 kw. generator.

Anniversaries, Floods, Short Circuits, Etc.

The year marked several important mileposts in the history of the electrical and related arts. It marked the fiftieth anniversary of the establishment of the alternating current system in America and of the Westinghouse Co. It also marked the fiftieth anniversary of the establishment of the electrical industry in Schenectady. Both of these anniversaries were celebrated with impressive ceremonies by the Westinghouse and General Electric Companies respectively. The year 1936 was also the fiftieth anniversary of the discovery of the Hall process for the commercial reduction of aluminum. Aside from the importance of the use of aluminum in electrical manufacturing, this metal is of considerable significance in the power field because of the current required in its manufacture. The amount of electric power used in the reduction of aluminum by the Hall process in this country is well over a billion kilowatt hours a year.

The significance and the importance of electric power was emphasized to a high degree in the disastrous floods which swept the country in the spring of last year. These floods placed heavy burdens on the utility systems and more than ever indicated the need and value of interconnection. More than that, however, they indicated the need of a more comprehensive system of flood control.

The most serious interruption to electrical service in years occurred in New York City early in the year when, at 4:16 p. m. on January 15 a ground occurred on one of the 13 kv. buses at Hell Gate Station. The resulting short circuit and blaze which followed and the electrical repercussions on the system put all but three generators in the station out of action at the outset and darkened Manhattan above 59th Street for hours. The accident naturally created a great deal of discussion and questions arose regarding the reliability of the alternating current system or the a.c. network. Whether or not any better system of electric power distribution may be possible, the accident served to emphasize the dangers inherent in the concentration of such enormous quantities of power. It raises the question of reserves and of the size of a network block of power that should be treated as a unit and brings out the necessity of using the utmost application of the principle of automatic sectionalization and isolation of any troubled part of a high capacity system.

The World Power Conference

Among the many meetings and technical conventions of electrical men, the most important last year was the meeting of the Third World Power Conference at Washington, D. C. in September. More than 2800 engineers and executives from 52 nations met at this conference to discuss "national power economy"—a notable gathering and apart from its technical significance, an achievement in the furtherance of good-will, friendships and understanding between the nations. The conference came to a dramatic close with President Roosevelt's pressing the button which set the Boulder Dam plant officially in operation. The speakers at this conference predicted a world wide improvement in the electrical industry and a great expansion in the usage of electric service during the next 15 years. This expected expansion in power consumption will take place through, 1, service to rural customers; 2, the development of electrical devices at present unknown; 3, rates which are progressively lowered, and 4, the substitution of electricity for steam in industry and in the railroads.

Steps were taken to honor the memory of two great electrical geniuses during the year, Edison and Steinmetz. Under the auspices of the Thomas Alva Edison Foundation, funds were raised for the creation of a memorial to Thomas Edison, and in New York State the home and effects of Charles P. Steinmetz in Schenectady were made a public museum of science by an act of the legislature.

So much for the non-technical side of the year's events in the electrical field. We have presented them here because they are as much a part of the year's happenings as the technical advances. In the articles that follow we shall consider the technical advances.

Technical Developments in

TECHNICAL PROGRESS in the electrical industry during the year 1936 proceeded on a broad front in all branches of the art. While there were many developments of outstanding importance the progress of the industry as a whole must be measured not by these outstanding achievements but rather by the steady improvement in all classes of equipment and technique of operation. It is difficult to state which development is important and which is not important. The year's developments for example include such widely separated items as an electrically heated honey knife, a monster electric shovel handling 50 t. at one scoop, a million dollar transformer, a twelve and a half million kilowatt man-made lightning stroke, a new lamp for sterilizing liquids, the first hydrogen cooled generators, a new "beam" electron tube, a 150,000 ampere electrical contactor, a method of drilling oil wells to a depth of 3 miles, etc. These are typical examples and we mention them here, not because we feel that these particular items are of more importance than others we might mention, but to indicate the wide diversity of the range of progress. The most important developments are not necessarily the most spectacular. This year perhaps the most important development in the electrical industry, as pointed out in the preceding article, is the remarkable increase in the construction of rural distribution lines. Urban electrification during the past two or three decades has reached a high degree of saturation and any further great increase in the use of electricity for domestic purposes among the urban population must come about through increased consumption and new applications. The rural population on the other hand has not had electrical service available to any considerable extent so this new activity in the construction of rural lines will undoubtedly open up a new era in the nationwide use of electrical energy. As more rural customers are added the cost of power to the farmers will decrease. With the extension of rural service will come a further unification and coordination of transmission and generating facilities throughout the nation. Notwithstanding the already high development of transmission technique, the problem of electric transmission is being given a great deal of attention and study at the present time. Whether the present alternating current systems will be superceded by some form of direct current transmission is a question which is receiving much more attention than it did a decade ago and its answer will depend upon further research and operation of systems now in course of development.

Generator Design

While the future course of electric transmission practice cannot definitely be charted, the principles of electric generation seem to have acquired a degree of stability which they will hold for a long time to come. The modern electric generator is a marvelously reliable and efficient machine. Except in methods of construction and in the use of better material, it has undergone no fundamental change for many years. The most recent improvement in electric generator practice is in the use of hydrogen as a cooling medium. The 50,000 kv-a. superposed unit for the Logan (W. Va.) plant of the Appalachian Electric Power Co. is the first commercial turbine-generator to be hydrogen cooled and its design was based on 12 yr. of planning. Hydrogen cooling is of particular advantage in these high speed (3600 r.p.m.) machines because hydrogen reduces the main items of loss, friction and windage, to one tenth of their value with air. Hydrogen cooling has been used successfully for a number of years in converter practice but there the problem is simpler in that it is unnecessary to effect a seal between the casing and the rotating shaft. The Logan generator is equipped with water cooled pads between the laminations of the armature.

Other hydrogen-cooled machines under construction include 66,666-kv-a., 3600 r.p.m. units for the Ohio Power Co. and for the West Penn Power Co., to be installed at Windsor (W. Va.) and a 31,250-

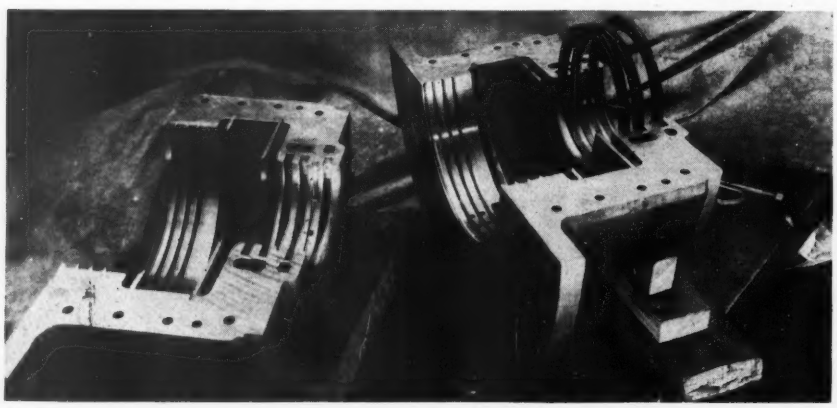


Fig. 1. View showing construction of seal between shaft and casing at hydrogen cooled generator (Photo, Westinghouse)

Electrical Equipment

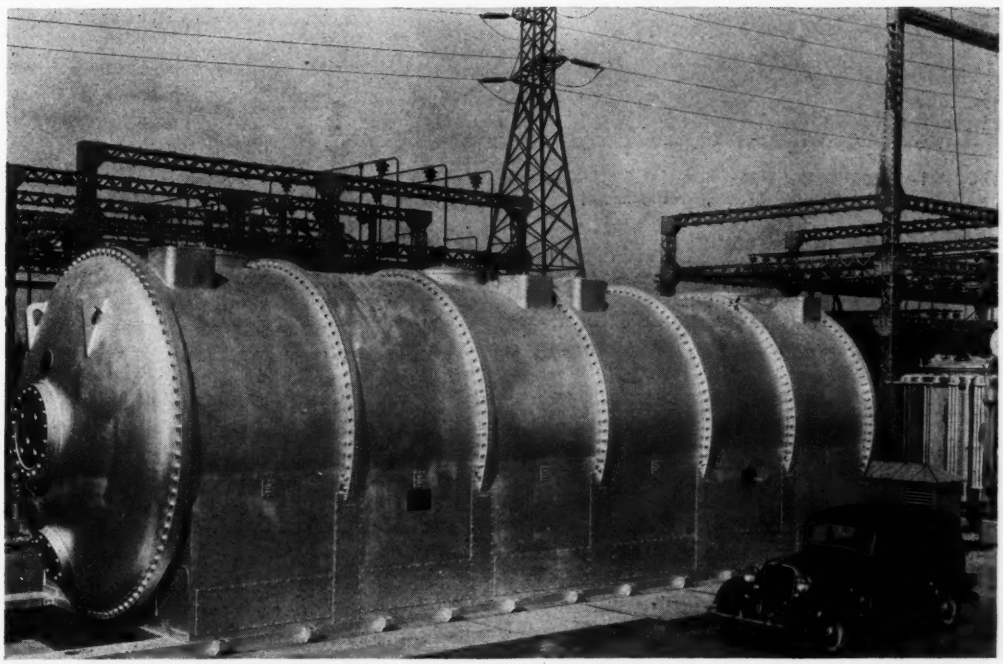


Fig. 2. New 60,000 kv-a. hydrogen cooled frequency changer for Boulder Dam line

Photo, Westinghouse

kv-a. generator for Dayton (O.). These machines differ from the Logan machine in that all cooling is done by surface hydrogen coolers of the familiar finned-tube type installed in the annular space within the generator housing. The water box, in the form of an elbow, projects through the hydrogen-tight outer shell. The cover plate and water connections can be removed to give access to the tubes for cleaning, without disturbing the hydrogen-tight portion of the generator. The finned tubes run lengthwise, parallel to the shaft of the machine, and fans on the rotor force cooled hydrogen into the "air gap" at two or three bands along the length of the machine.

A 10,000-kw., 3600 r.p.m. unit was installed during the year for the Weirton Steel Co. It also is a topping turbine designed for steam conditions of 800 lb. ga., 800 deg. F. total temperature, and 215 lb. ga. back pressure.

The year produced no electric generators of unusual size. The second 110,000 kw. vertical compound turbine-generator installed during the year was the largest unit installed but this is composed of two 55,000 kw. generators. The 183,333 kv-a. generator at Richmond installed in 1935 still holds the world's record for size. A 50,000 kw. generator is being built for the Waterside (N. Y. Edison) top plant and a 75,000 kw. unit is in course of construction for Cahokia Station in St. Louis.

In the hydroelectric field, the 82,500 kw., 16,500 v. main units at Boulder Dam, the first two of which went into operation in October, are the largest hydraulic generating units in the world. Much has been written about these machines and little more need be said about them here. In addition to their great capacity, however, these machines attain a new high record in efficiency between water intake and station busbars which is startling. In this machine and its duplicates, the guaranteed efficiency of the generator alone is 97 per cent, and this, combined with the high efficiency attained by the hydraulic turbine, makes it possible to deliver in the form of useful energy at the busbars more than 90 per cent of the total potential energy of the falling water.

Transformers and Converting Apparatus

Transformer construction reached new heights in 1936 in the installation of the first groups of transformers for Boulder Dam. These groups consisted of seven 65,000 kv-a., 287,500 v. auto-transformers and seven 55,000 kv-a., 287,500 v. transformers. These are the largest and highest voltage transformers in the world. The 65,000 kv-a. auto-transformers cost in the neighborhood of one million dollars each. The seven 55,000 kv-a. units are water cooled while the seven 65,000 kv-a. units are oil cooled.

The shipment from the factory to Los Angeles of the core, coils and insulation assembly of the 65,000 kv-a. auto-transformers was made in the lower section

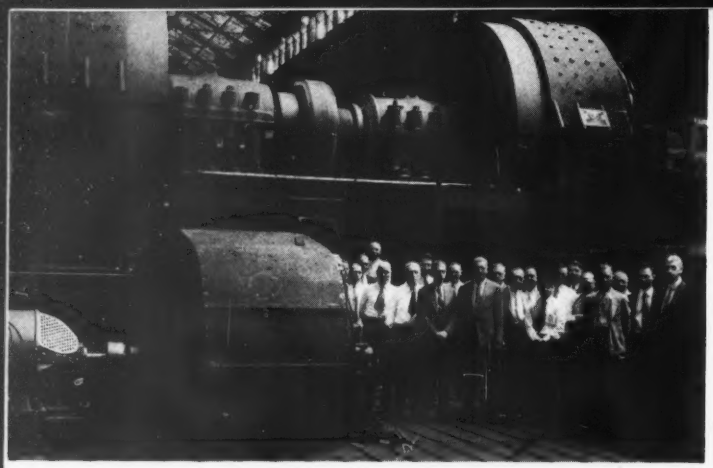


Fig. 3. Two 7000 hp. d.c. motors for steel mill service on test in the factory. (Photo, Westinghouse)

of their own tanks in dry nitrogen so as to eliminate the necessity for drying out in the field. In the case of the 55,000 kv-a. units, however, the shipment was made in specially designed tank cars on high speed trains, also in nitrogen. On arrival they were placed in their own tanks and filled with oil.

The initial installation of transformers for the T.V.A. at Norris Dam also was completed. There are six, single phase, self-cooled units rated at 18,667 kv-a., 154,000 v.

A 3 phase, air-pressure-cooled transformer of unusual design was completed for the Consolidated Gas, Electric Light and Power Co. of Baltimore. It is rated at 53,333 kv-a., 69,000 Y/115,000 Y-34,500 Y-13,800 v. The 13,800 v. winding has a capacity of 18,667 kv-a. The 34,500 v. winding is provided with load ratio control to give plus or minus in four 2½ per cent steps. Cooling is obtained by 3 banks of radiators with an air blower for each bank.

In conversion equipment, the 60,000 kv-a. hydrogen cooled frequency changers, also for the City of Los Angeles for the Boulder Dam line, marked the high point in the year's development. These units, operating at 600 r.p.m., consist of 60 cycle, 60,000 kv-a., 13.2 kw., 3 phase, 0.8 p.f. generators and a 11.5 kv., 3 phase 0.9 p.f. 50 cycle motors.

There has been considerable development during the year in the application of the mercury arc rectifier to industrial services. A number of these units were installed in office buildings for elevator service. A 1000 kw., 250 v. unit was installed in a middle western steel mill to supply direct current power to a new wire mill. An interesting feature of this installation is that the d.c. voltage at the motor terminals is maintained at a predetermined constant value by means of automatic grid voltage control on the rectifier. The quick response of the grid control and the high part load efficiency of the mercury arc rectifier are important factors in its application.

Similar rectifiers but rated at 2000 kv-a., 630 v. were installed in the new substation supplying current to the high speed traction line across the Delaware River bridge between Camden and Philadelphia.

Electric Transmission and Distribution

The event of outstanding importance in the field of electric power transmission in 1936 was the inauguration of service over the 266 mile line between Boulder Dam and Los Angeles on October 9. This marked the beginning of operation of the longest and highest voltage transmission line in the world, and the event was heralded by a great celebration by the people of Los Angeles. More than a million people, it was estimated, turned out upon this occasion. The actual amount of power transmitted over this line thus far has been small because only one of the Boulder Dam generators has been in operation, so it is too early to present any facts in regard to the actual operation of this line.

No unusual developments in the field of transmission occurred during the year. The constant current direct system developed by the General Electric Co. during the last two years has undergone further test and an actual line using this system has been in operation during the year. The operation was in accordance with that anticipated from previous small scale and design data.

This development, naturally, has been the cause of a great deal of interesting speculation as to its probable use in the future. At the time of the serious short circuit at Hell Gate Station in New York last January there was much discussion regarding the danger of high concentrations of energy in alternating current systems such as that in New York City and the use of a constant current direct current system was suggested as a possible alternative. Naturally, most of this was pure conjecture but the fact that these discussions took place serves to indicate that the whole problem of transmission and distribution is still in a healthy state of development. As a matter of fact, at the very time that this interest in direct current transmission exists, some of the larger cities are changing the old Edison direct current distribution systems over the a.c. networks. Conversion of this kind is in progress in Chicago at the present time.

Much attention is being given the modernization of transmission and distribution lines. During the past ten years a vast amount of knowledge has been gained regarding transmission line construction and operation especially with respect to the element of protection.

An element of particular interest in distribution practice is the use of shunt capacitors on distribution circuits. The effect of power factor on ordinary distribution circuits has not been fully appreciated and full advantage has not been taken of power correction methods available today. While the value of the shunt capacitor as a corrective device has been known for many years its greatest usefulness to the power industry has been restricted by certain limitations in size and cost. Important improvements in the art of manufacture and substantial reductions in costs now make capacitors available for use on distribution circuits.

During the past year the Union Electric Light and Power Co. applied 21 shunt capacitors to their distribution circuit, ranging in capacity from 120 to 180 kv-a. These units are mounted on poles where they apply to overload lines just like the ordinary distribution transformer, and they are protected with fuse cutouts and lightning arresters in the conventional manner. The performance of these units has been very satisfactory. In one particular instance the installation of two 180 kv-a. capacitors on a 4 kv. feeder reduced the secondary voltage drop from 7.8 v. to 4.6 v.

and resulted in an increase of feeder capacity of approximately 500 kw. at normal power factor. The proper amount of increased load carrying ability was provided to take care of the present and near future requirements at $7 per kilowatt, rather than accepting the alternative of presently providing an excess amount of capacity at an out-of-pocket cost of $16.20 per kw.

The great reductions recently made in the bulk, weight and cost of capacitors has also extended the use of the series capacitor in distribution practice.[1] In this application the capacitor serves as a line voltage regulator. Because of its instantaneous action the series capacitor is particularly useful in preventing the voltage dips that ordinarily occur when large motor loads are connected to the line. As shown in Fig. 4 by placing the series capacitor about one third

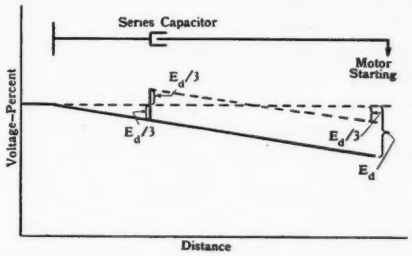


Fig. 4. Showing the effect of series capacitor as a line voltage regulator

of the electrical distance between the source and the load, the voltages on both sides of it are kept within plus and minus limits in which flicker is not objectionable.

Rural Lines

As already indicated, the most important development in the field of electric transmission and distribution has been the enormous increase in rural line construction. Aside from the direct stimulus provided by the financial resources of the R.E.A. and the efforts of the power companies in promoting this class of service, an important factor in this development is the simplification in equipment and the consequent reduction of investment costs. This simplification involves not only the lines themselves but also farm wiring. Not only has there been development in the design of less expensive equipment but a different attitude is being taken in regard to the significance of what constitutes adequate wiring.

The relatively low cost of knob and tube work and of non-metallic sheathed cable is of significance in rural areas. Knob and tube work is highly satisfactory for farm buildings and its use should be encouraged. In many sections of the country, however, the installation of knob and tube work has become practically a lost art and the use of non-metallic sheathed cable is probably to be preferred. Whereas armored cable may be used only in dry locations, non-metallic sheathed cable may be used in every part of a farm building whether moist, wet or dry and is prohibited only outdoors and underground. Several new simplified non-metallic assemblies of cable are now available.

The same considerations which govern farm wiring also cover farm line construction. As a consequence, new types of pole construction have been developed, the single bushing transformer has made its appearance, new conductors permitting longer spans have been made available and simplifications in protective and metering practices have been developed. Due to these new designs and methods the cost of rural line construction has been reduced from $1000 to $2000 per mile to as low at $632 per mile.

Advancements in the Use of Carrier

The year witnessed unusual progress in the development and application of carrier and allied apparatus. In the low frequency field, control apparatus was expanded in design to meet more adequately and flexibly the growing demand in connection with domestic off-peak water heating. In the high frequency field telephone apparatus was further refined in design and its possibilities widely broadened. A new equipment was developed for use in power-line relaying and much progress was made in the application of carrier current to problems of remote control and indication. Of outstanding significance was the installation of carrier relaying and coupling capacitors with associated potential devices on the Boulder Dam 287.5 kv. lines and the Norris-Wheeler-Wilson Dam 154 kv. lines of the T.V.A.

In the field of voice communication a development of interest is a line of patrol car carrier receivers to provide for one way reception in a mobile unit near the transmission lines. This receiver embodies the high sensitivity of the police car receiver and its installation and operation in the patrol car is essentially identical with that of the modern police receiver. A new semi-portable simplex carrier was also developed to provide 2-way "dead-line" communication between repair crews and terminal stations during line repair work. Operated from a 6-volt battery, this weather proof apparatus may be transported by truck or carried by two men to the desired site. This equipment is used over de-energized transmission lines whose ground chains are provided with a new design of portable grounding trap which solidly grounds the line at 60 cycles but not at carrier frequencies.

[1]See Fig. 2, page 21 of this issue.

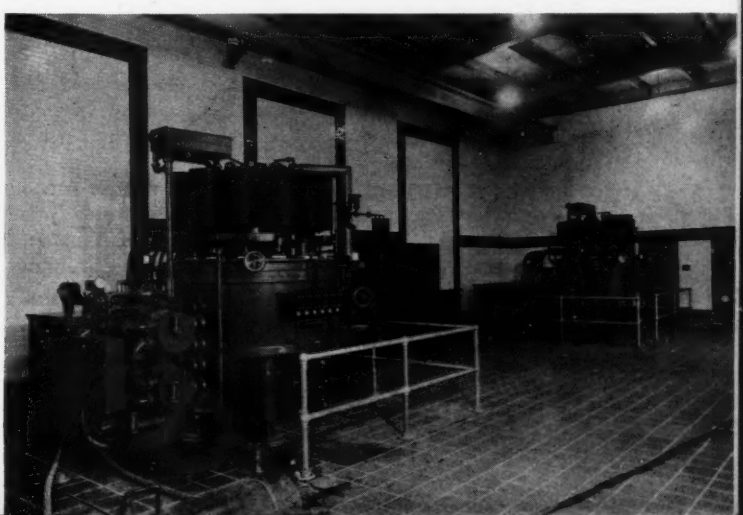
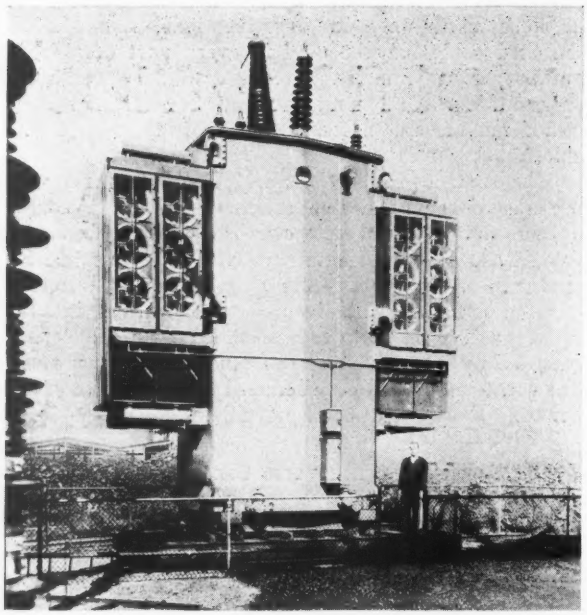


Fig. 5. Grid controlled mercury arc rectifiers in Philadelphia traction substation. (Photo, courtesy Allis-Chalmers)



Photo, Westinghouse

Fig. 6. 65,000 kv-a. auto-transformer installed in the Boulder Dam system.

Advancements in the Design and Application of Electric Motors

In the field of motor applications, two outstanding installations made during the year were in steel mills, one for the Homestead plant of the Carnegie-Illinois Steel Co. and the other for a mid-western steel plant. These installations involved two 7000 hp. direct current motors of the reversing mill type, capable of decelerating from top speed in one direction and accelerating to top speed in the opposite direction in six seconds. These two motors are among the largest and most powerful ever built. An interesting feature of these units was the method of testing them at the factory. Since there were two of them, it was possible to couple them together so that one acting as a motor drove the other as a generator, thus making it necessary to supply only the losses. They have a full load efficiency of 93 per cent and operate at 40/80 r.p.m.

For use with high-torque applications involving limited power supply, an interesting development was a duo-synchronous motor rated at 1250 hp., 1.0 p.f., 900 r.p.m., 440 v. This machine has a revolving armature with spiralled coils, a stationary field with a heavy low resistance stationary insulated phase wound amortisseur winding connected to an external multi-step starting resistor of high heat storage capacity. With this construction, starting torque of about 180 per cent full load torque is produced with a current drawn from the line of about 250 per cent of full load current. An initial low-torque "cushion" step to take up any play in the mechanical transmission is also provided.

There were many developments and refinements in the construction of all types and sizes of motors. Some of these are concerned with specific applications and involve such features as dust and moisture proofing, explosion proofing and special provisions for high speed. A new Rayon spindle motor for example which has a reinforced Textolite bucket and a Glyptol insulated 3-conductor cable is capable of operating at a speed of 10,000 r.p.m. Other motor developments have to do with standardization and interchangeability of parts. A wound rotor induction motor was built which utilizes a rotor construction similar to that used for high speed turbo-alternators and a forced-oil lubrication system.

Further improvements in capacitor design made it possible to again reduce the space required by capacitors on fractional-horsepower capacitor-type fractional horsepower motors.

A new thermal overload switch for fractional horsepower motors known as the "thermotector" is an automatically reset thermal overload switch operating on the line current of the motor. This device automatically disconnects the motor from the line on overload before the motor reaches a dangerous temperature and, when the motor has cooled, automatically reconnects it to the line.

One manufacturer brought out a new line of induction motors employing an insulation system "built from the inside out" on the stator coils. These coils are of the random wound type with joints at the connections fused instead of soldered. Recently developed insulating materials and processes are utilized, eliminating the need for taping the end windings and producing an insulation assembly with high resistance to moisture, mild acids, alkalis, oil and abrasion.

Switchgear Developments

In switchgear as in transformers and other equipment, the high point in the year's development was attained in the installation of the 2,500,000 kv-a., 287,500 v. oil blast and De-ion circuit breakers on the Boulder Dam line. These units break all records for size, voltage, speed and interrupting capacity, and their successful performance is ample testimony to the correctness of the fundamental principles involved in the design of these units. It is extremely interesting to see how the requirements demanded in these breakers were successfully met by two manufacturers by two different methods of approach. In the case of General Electric, the oil blast principle was used; Westinghouse, on the other hand, employed the De-ion principle of Slepian.

The main cricuit breakers on the Boulder Dam line, however, were only a part of the switching problem. The design of the disconnecting switches also involved problems which required all the skill of the electrical engineer in their solution. The severity of desert climatic conditions and the high voltage to be handled required many departures from established practice in the design of these enormous disconnects. In addition to such factors as the prevention of corona which would cause serious radio interference, consideration had to be given to such unusual factors as earthquake stresses. The contacts on these switches are made of heavy wrought silver made integral with the copper base contact bars.

An interesting feature of the year's achievements in switching equipment was the construction of a 150,000 amp. contactor. This contactor is used in connection with the homopolar generator mentioned in last year's review issue in an electric pipe welding

process. This unit has a continuous capacity of 150,000 amp. and an intermittent rating of 200,000 amp. at 10 v. d.c. It is capable of closing frequently and opening the full current with practically no signs of contact burning.

The general appearance of switchboards was improved by a more extensive use of semiflush equipment. Meter and relay cases for semiflush mounting were redesigned so that the flange now supports the device eliminating the mounting supports formerly used, and so that the covers can be removed easily from the front.

At the opposite end of the switch field are the small vacuum switches which have been used to an increasing extent in specialized applications. Switch contacts operating in a vacuum are particularly suited to the opening of low power direct current circuits where the actuating motion is of small amplitude and slow, as from a thermal strip or very slow moving cam. Two forms of vacuum switch are now available, an all metal type and one for higher voltage constructed partly of glass.

Fig. 1. A cold cathode arc discharge tube. This tube requires neither power nor time for heating the cathode, but in which a discharge of several hundred amperes is controlled by an extremely small amount of power in the grid circuit. (Photo, courtesy H. E. Edgerton, M.I.T.)

Control and Regulating Equipment

The scope of electric control equipment is so great and its character so varied that in an article of this length it is possible to touch upon only a few of the more important developments more directly concerned with the power industry. As pointed out in another article in this issue the element of electric control is one that is interrelated with almost every other element of the power system and often it is impossible to separate the item of control from the specific equipment it is associated with.

If any one thing in the electric control field stands out above all the other developments it is the steadily increasing use of electron tubes. In all branches of the field, whether it be in manufacturing processes such as welding or in the control and regulation of voltage, the electron tube is finding increased application each day. For example, in the application of resistance welding to the fabrication of aluminum alloys the greatest accuracy of control is required. To this end, a development of this year was a combination spot and seam welding control unit, using power tubes. For spot welding it is adjustable in half cycle steps while for seam welding both the "on" and "off" timing are adjustable in half cycle steps. It is equipped with water-cooled, sealed-off ignitron power tubes located in the primary circuit of the power transformer.

In another instance, a low range direct current welder was developed using rectifier tubes instead of rotating equipment. This welder uses four mercury Tungar tubes.

These examples of the use of tubes in welding equipment are typical of what is taking place in other types of control equipment. The thyratron, the ignitron, the photoelectric cell are gradually assuming more important functions in many types of control equipment and always with an improvement in performance.

Development in electron tube practice were numerous. It included the development of new tubes, such as a cold cathode, arc discharge tube, new ultra-high frequency tubes, beam power tubes, and new cathode ray tubes. In the application of tubes, there were new electron tube voltage regulators, dozens of applications in instruments and recorders. There were new light and radiation measuring devices, all sorts of industrial applications, electromedical equipment of a wide variety.

Among the various new developments in photoelectric relays one of particular interest is a standard line of units which do not require an amplifier tube. The impulse from the phototube is impressed directly upon the grid of a four-element inert-gas-filled thyratron tube which controls a magnetic contactor capable of making or breaking 35 amp. a.c. or carrying 10 amp. continuously.

A new Selsyn control was developed which on 60 cycle power gives plus or minus five degree accuracy, a safe operating torque of 12 in.-oz. at 25 deg. displacement, and a maximum synchronizing torque of 65 in.-oz. at 110 deg. displacement. Hundreds of these units have already been installed in steel mills.

Among the new device developments was a time delay push button designed for use in connection with a magnetic motor starter to prevent shutdowns on voltage disturbances of short duration.

Several new lines of voltage regulators made their appearance during the year. Among these, one of particular interest is a line of branch feeder step-voltage boosters for use on 2400, 4800 and 6900 v. circuits. This regulator consists of a tapped auto-transformer connected to a two position oil immersed contactor which is actuated by a resonant relay control. In order to provide a path for the load current during the brief switching interval, a Thyrite by-pass is connected in parallel with the contactor. The full load current passes through the Thyrite by-pass during switching, thereby providing continuity of service. The resonant relay control comprises a saturating reactor, capacitor and resistor, connected in series. This combination is resonant at a certain voltage and becomes dissonant at a lower value of voltage.

From Tensors to Heartbeats

Nothing is more vital to the continued progress of the Electrical Industry than Research. As carried on in the laboratories today, electrical research covers almost every branch of human activity.

WHY DOES the United States, with only 7 per cent of the world's population consume more than 30 per cent of the electrical energy produced in the world? Why does a turbo generator today require only 1 lb. of coal per kw-hr. against 3 lb. per kw-hr. in 1902? Why does a capacitor which weighed 2260 lb. and cost $2325 in 1924 weigh only 660 lb. and cost only $1032 today? Why does a 100 candlepower lamp use only 100 watts and cost only 20 cents today when it used 310 watts and cost $3.50 forty years ago?

The answers to all of these questions and many others like them is "research"—electrical research. Research has saved more money, paid greater dividends, relieved men of more drudgery, added more to the comfort and happiness of humanity than any other single factor in civilization.

The rapidity with which the electrical industry advanced in the last 40 years was due in large measure to mathematical research—to the work that Charles Proteus Steinmetz did in developing and teaching the mathematics of complex numbers. This provided a method for dealing, mathematically, with the design of alternating current machinery.

Knowing this, no observer, however casual, of developments in the electrical field can fail to have been impressed by the significance of a new method of mathematical analysis which, recently, has made its appearance in electrical literature. This new method is startling in its printed appearance and impresses one as being extremely formidable but its proponents insist that this is not so, that, fundamentally its principles are easy to grasp. This new mathematical method is called "Tensor Analysis."

Just as the complex numbers of Kennelly and Steinmetz, the operational calculus of Heaviside and the symmetrical components of Fortescue proved invaluable in the past development of electrical engineering, so tensor analysis, as interpreted by Gabriel Kron now provides another effective means for its further extension. Its application to electrical engineering is due largely to Gabriel Kron and he has been its chief proponent. During the past year, however, several others have employed the method to advantage and its use will undoubtedly increase.

One's first reaction to the bewildering arrays of symbols which characterize tensor mathematics is much the same as that which we experience in opening a book by Gertrude Stein, but we are assured that, tensors can be reduced to useful purposes whereas we still insist that this is impossible in the case of Miss Stein's writings. Tensor analysis seems to make a clean sweep of many of the difficulties that heretofore have hindered the solution of complicated problems. An entire network or all the windings and circuits of an electrical machine can be represented by a single single tensor equation. It is a generalization of vector

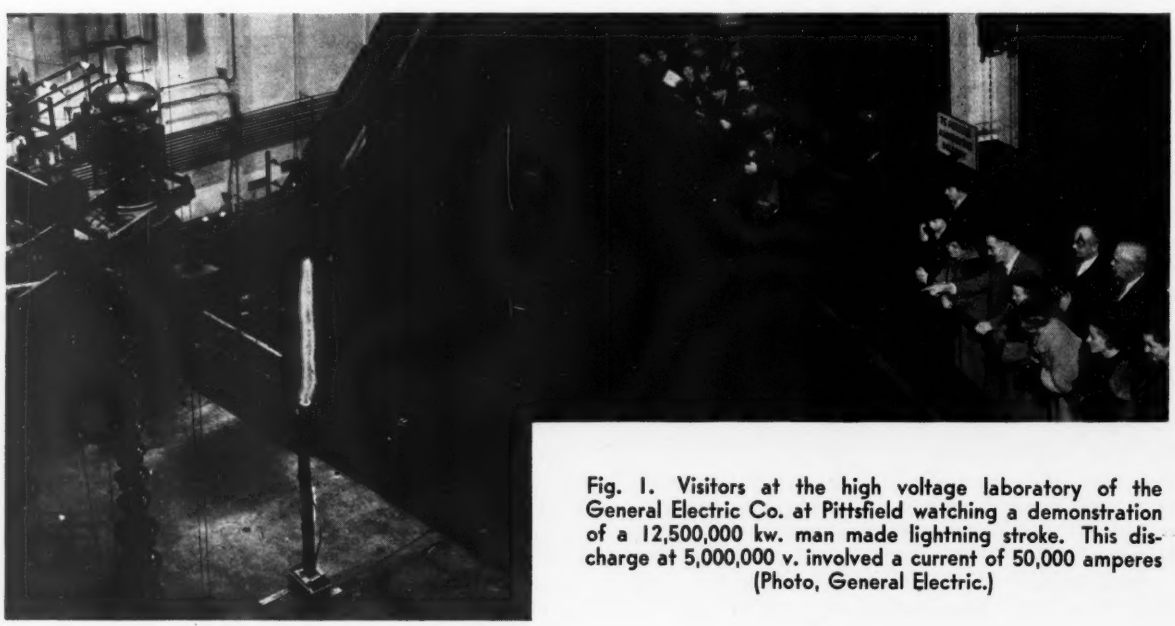
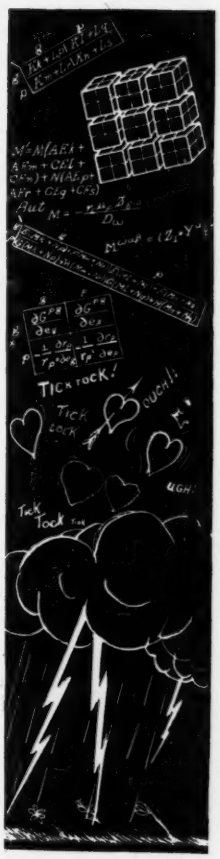


Fig. 1. Visitors at the high voltage laboratory of the General Electric Co. at Pittsfield watching a demonstration of a 12,500,000 kw. man made lightning stroke. This discharge at 5,000,000 v. involved a current of 50,000 amperes (Photo, General Electric.)

and Thunderstorms



analysis, and as its proponents put it, "once the physics for the simplest case is given, tensor analysis permits immediate generalization to the most complex ramifications of that case." Its rules are said to be simple and so clear that they are self-evident and self-checking.

In speaking of tensors here, we do not claim to understand them but we have sufficient confidence in those who are developing this new mathematical tool, as to believe all they claim for it. It may seem curious to some that we should discuss this subject here, at the beginning of an article which purports to review electrical research but for this we make on apology. The further development and use of tensors this past year, to us is a very important factor in the progress of electrical engineering, of far greater significance than mere changes in the mechanical or electrical construction of machines. For here, we are dealing with the very foundation upon which the entire art rests. It is encouraging to know that the electrical art is still subject to such influences as these for it is an indication of its virility.

From the rigorous logic of tensor analysis at one end of the electrical art, so to speak, we pass to such an entirely different branch of research as that which involves the effects of electric currents on living tissues and living organisms. Until quite recently very little was known regarding the effect of electric shock, indeed the only knowledge available was derived from the haphazard conclusions drawn from cases of accidental shock or in the case of electrocution of criminals. Neither of these aspects provided any useful data. Several years ago at Johns Hopkins some serious investigations in regard to the effects of shock were started and these have continued. During the past year we have seen a considerable amount of research in this field and much useful data has resulted. At Johns Hopkins, at Yale and at Columbia different aspects of the subject have been studied. The investigations at Columbia made by members of the staff jointly with members of the Bell Telephone Laboratories are of particular interest, since they had as their object, the effect of electric shock upon the heart. It was found that electric shock may derange heart action without damage to heart tissue, a condition known as ventricular fibrillation, but which, in the absence of restorative measures results in death within a few minutes. This in itself is not surprising. It was shown, however, that if the heart was subjected to a subsequent "counter" shock of high intensity and short duration, the fibrillation is arrested and the animal fully recovers.

Perhaps this field of investigation seems far removed from power production but a moment's reflection will prove that this is not true. No person should know more about the effects of electric shock than those engaged in the production of electricity since they are most exposed to the dangers of accidental shock. Few things have saved more people from death due to electric shock than knowledge on the part of operators and linemen of the prone pressure method of resuscitation. Perhaps in these new electro-biological investigations lies the way toward even more effective methods of saving human lives.

In still another direction of electrical development is the great progress made during the year in the field of lighting research, in our knowledge of the mechanism of thunderstorms. Here we have in mind not so much the systematic study of the effects of lightning and the protective value of various types of equipment, nor even the astonishing developments in simulating the lightning stroke in the laboratory, but rather, the study of actual thunderstorm phenomena in nature. Until recently too little attention was paid by engineers to the problem of the direct stroke and how the lightning discharge itself is formed. They were, of necessity, preoccupied with methods of preventing damage to transmission lines by direct or indirect lightning strokes. During the past few years, however, activity in study of the lightning stroke itself has increased materially and a number of investigators are at work on these phases of the problem. Chief in this field is K. E. McEachron and his associates at the Pittsfield Lightning laboratory of the General Electric Co. This laboratory itself is a notable achievement in lightning research and in this, its first full year of operation, it has contributed to a considerably better understanding of the problem of the thunderstorm. Of particular interest are the recent photographic studies of the propagation of direct strokes. These show that the lightning discharge is initiated by a leader stroke which builds up from the cloud to the earth in a series of jumps. The earth prepares to receive this stroke as streamers begin to form on the earth's surface when the cloud streamer is but a few hundred feet away. Photographs showing these earth streamers were actually obtained.

Much valuable information in this field also has been obtained by the further use of the Boys camera, which incorporates a stationary optical system and a high speed moving photographic film. Many lightning strokes have, by means of this camera, been shown to consist of as many as 40 separate discharges in quick succession.

To one who has not followed recent progress in this field, the amount of exact or reasonably exact knowledge regarding the lightning discharge is quite

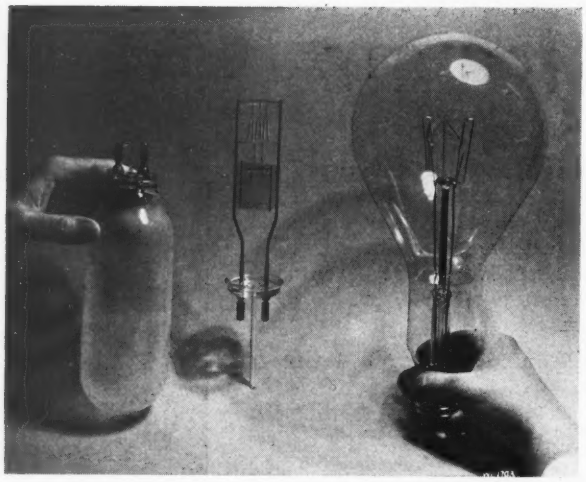


Fig. 2. Grids for incandescent lamps! A new product of research. The grid below the filament serves to condense the sublimated filament material thus preventing blackening of the bulb. (Photo, Westinghouse)

astonishing. For instance, the potential of a thunder cloud is of the order of 100,000,000 to 1,000,000,000 v. The direct stroke currents run from 3000 to 200,000 amp.; the average rate of current change, 4500 amp. per microsecond with a maximum rate of change of 40,000 amperes per microsecond. The total charge varies from 0.05 to 20 coulombs in a single discharge. The polarity is usually unidirectional but it may change between successive discharges of a multiple stroke. Strokes to transmission lines are about 95 per cent negative. A high percentage of strokes to ground are multiple strokes, with the interval between discharge from 0.0006 sec. to 0.53 sec. The first discharge has a stepped leader which has a velocity of propagation toward the earth of the order of 50 meters per microsecond. The intervals been steps are about 100 microseconds and the length of each step about 50 meters. The main stroke builds up from earth toward cloud at about 20 to 140 meters per microsecond and on the average it reaches only about three quarters of the distance back to the cloud.

So much for actual lightning strokes. In the laboratory, the most important achievement in the field of lightning research was the production of a 12,500,000 kw. discharge. This involved a current of 50,000 amp. at 5,000,000 v. The power represented in this stroke was approximately equal to the average output of all the utility supply stations in this country.

From this brief discussion it must not be assumed that all the mysteries of lightning have been solved. As more knowledge is gained new problems open up and this will remain a fertile field for investigation for a long time to come. We have, here, merely endeavored to indicate the broad front on which research is proceeding. Tensors, heartbeats and thunderstorms are far removed from the work of the practical man in the power plant but no more, perhaps, than were Faraday's experiments with a coil of wire and a rotating disc.

But all research is not so far removed from everyday engineering work as the three examples cited above. A great deal of important work on new materials is being carried on for example. Many new synthetic plastic materials such as cellulose acetate, metal alloys have been produced and research in plastics continues to provide promise of still better electrical insulators. Chemists and engineers have watched for several years the development of flexible Glyptal, Duprene, and Thiokel. Flamenol is a newcomer in this field. Rubber-like in many respects, Flamenol can be made very soft and flexible, or with a celluloid-like rigidity. It can be put into solution for coating, impregnating and can be compounded, filled, calendered and extruded. It is water-acid-alkali-, and oil-resistant. It is tenacious, has good tensile strength and has good dielectric strength. It does not support combustion, its life is long as it does not oxidize even in the presence of ozone and it is therefore unaffected by corona discharges.

A new group of alloys known as Trodaloy, composed of cobalt, beryllium and copper, combines high tensile properties with high electrical conductivity. Its immediate application was that of resistance welding electrodes for welding stainless steel. Another Trodaloy is finding a place in the field of high conductivity springs and strong, high conductivity "copper" castings.

In the field of physics, extensive investigations of the space charges and other phenomena occurring in electric and magnetic fields have been carried on. A theory that explains the hitherto puzzling decrease in current in a magnetron well below its cutoff point, when the current is space charge limited, has been developed. The oscillations and bursting of bubbles or droplets placed in a strong field have been quantitatively explained on the basis of the theory of electric discharges from points and the behavior of various metals used to anchor the cathode spot in mercury rectifiers has been described.

A new high speed photographic method of measuring arc temperatures, observing the wave front of a sound wave passing through the arc, yielded valuable information on welding phenomena. Average temperatures of cored-carbon and tungsten arcs were found to be 5500 K and 6440 K respectively.

Fluorescent lighting by reflection of the ultra violet rays of a mercury arc light from a fluorescent reflecting surface as visible wavelengths has made great strides. The ultraviolet energy going to waste in a standard mercury-vapor lamp amounts to 1½ times the quantity of visible light so that materials such as rhodamine, eosin and primulin dyes, etc., used as reflectors enable a considerable visible light output over a wide range of colors to be obtained, supplementary to the normally visible green light. Limitations of present materials make this new form of lighting so far chiefly useful for securing subtle and pleasing color effects, but there are great future possibilities if improved fluorescent materials having less visible light absorption and greater reflective efficiency can be produced. Unfortunately the infra-red wavelengths of incandesecent lamps cannot be used to produce visible light in this way, as the atomic frequency transformations that cause fluorescence can only work in the downhill direction toward lower frequencies.

Research with sodium alloys in vapor lamps has opened up new possibilities for obtaining high-efficiency lighting with good color values.

Water cooled capillary lamps, although not available commercially, were operated in the laboratory at

high efficiency and high intrinsic brilliancy. A 600 w. lamp produced 30,000 lumens from an arc gap one cm. long and the brightness of the core of the arc was 40,000 candles per sq. cm.

For radiographic examination of welds and castings a new 200,000 v. oil-immersed completely shockproof industrial X-ray unit was introduced. Another development in the X-ray field was the development of a 3-electrode Coolidge X-ray tube, made possible by the building of a self-rectified 200,000 v. completely oil-immersed therapy unit.

In the field of chemical research extensive work has been done on the problem of oil oxidation, with the object of understanding the mechanism of the process and, if possible, of controlling it. Tests have shown that the presence of a small amount of an inhibitor such as phenylalpha-naphthylamine delays the start of oxidation of white oils for a definite time, but that once started the volume of oxygen absorbed

Fig. 3. Examining a tree trunk shattered by the artificial lightning bolt shown in Fig. 1. (Photo, General Electric)

increases closely as the square of the elapsed time. On the other hand, the oxidation rates of some lubricating oils were found to be constant, independent of the time. Further experiments showed that copper has a marked catalytic effect, increasing the oxidation rate several fold, while iron, tin and lead have smaller but positive accelerating effects.

Important advances in the technique of chemical investigation have been made, enabling minute samples of materials, only a few millionths of a gram in weight to be analyzed almost as completely as samples many grams in weight have been in the past. Electrolysis, fractional distillation of single drops absorbed by asbestos fibers and spot analyses by taking a print of the specimen on paper impregnated with a sensitive reagent are some of the novel methods used in the new microchemistry.

Electrical research is closely associated with electrical instruments and this year a number of very interesting developments were made in the field of measurement. Of particular interest for example is the so-called memory oscillograph. The preliminary development on this device was covered in our review issue last year but this year further development has brought it to a commercial stage. With this device, electrical events of uncertain time of occurrence and of high speed are successfully recorded.

Three high-vacuum permanently-sealed cathode-ray tubes with fluorescent screens having adequate persistence of fluorescence are utilized. The recurring time axis from a built-in saw-tooth wave oscillator, when interlocked with the frequency of the circuit being investigated, provides for a continuously traced image of the voltages or currents being studied. By means of a mirror system the traces on all three fluorescent screens are photographed with a single camera. The camera shutter, which is normally closed, is triggered to open for a snapshot of all three fluorescent screens when the circuit disturbance to be recorded occurs. This triggering of the shutter is accomplished through a thyratron controlled relay circuit actuated by the disturbance. The adequate persistence of fluorescence of the tube screen provides for the retention of the image of the event sufficiently long to open the shutter and accomplish the camera recording.

A number of special purpose cathode-ray oscillographs marked the year's instrument developments. One of these is designed for the purpose of recording recovery voltages on power systems in connection with expulsion-gap tests; it is a 3-phase cathode ray oscillograph having many novel features including photography external to the vacuum.

An improved photoelectric smoke-density indicating and recording equipment consists of two units, a light source and a photoelectric amplifier mounted opposite each other across the stack breeching. The light source provides the intense beam of light necessary for operation over 20 to 30 ft. distances commonly encountered. To facilitate the training of the beam on the photoelectric relay after the light source enclosure has been rigidly mounted, the light source is equipped with independent vertical and horizontal adjustments which hold it rigidly in position.

The photoelectric relay possesses many features which cannot readily be obtained through the use of an ordinary relay. The amplifier is connected inversely so that a decrease in light from the phototube, resulting from increased smoke density, will cause the needle of an indicating meter to move up scale, thus indicating directly the increase in smoke density.

An alarm relay is provided with this equipment to operate warning signals when an objectionable smoke density has been reached. This alarm relay is actuated by a thyratron tube, which makes the relay highly sensitive to changes in smoke density.

A photoelectric hysteresigraph was designed for use in obtaining data on magnetic materials. Direct-current hysteresis loops are obtained photographically as the material is slowly carried through the desired magnetization cycle. Either major or minor hysteresis loops may be obtained. Bar or strip samples may be used with a permeameter, or ring samples may be used.

The device consists of two photo-electric flux meters, one for measurement of flux density, and the other for measurement of magnetizing force, connected to a cathode-ray oscillograph, so that one produces vertical deflection and the other horizontal deflection. The photoelectric flux meter employs a ballistic galvanometer combined with a photoelectric control system.

Hydro Plants Produce Over

Large federal and state hydroelectric projects now under construction, factors in a comprehensive scheme for more effective use of our water resources

"I GIVE THEE LIFE," said President Roosevelt, pressing a key at Washington on September 11, and at that instant over two thousand miles away at Boulder Dam, twelve needle valves opened, each releasing an 8 ft. cylinder of water—Boulder Dam had been officially opened.

The official opening of Boulder Dam undoubtedly was the event of greatest importance in the hydroelectric field in the year 1936 since it marked the successful completion of a plan and program that had its inception some 35 yr. ago. For the Boulder Dam project is not a recent development; it goes back as far as 1902 when President Theodore Roosevelt signed the Reclamation Act and when investigations for the control of the Colorado River were started. Boulder Dam is of interest to us here because of its power aspect but of course from a national standpoint this development has implications which extend far beyond the question of power development. The dam is a vital necessity whether power is generated or not, and with its completion the residents in the Imperial Valley can rest assured that the menace of the Colorado River which overhung their existence for so many years has now been removed for all time.

This aspect of the Boulder Dam project is one that should be considered in evaluating the significance of any of the large federal hydraulic projects now being constructed or planned. To regard the economic significance of these projects on a kilowatt per dollars basis is meaningless for the value of these projects can be measured only in terms of human and national welfare.

The importance of the planned utilization of water resources is becoming more generally recognized throughout the world and in this country such projects as Boulder Dam, Wheeler and Norris Dams of the T.V.A. and the great developments on the Columbia River are beginnings in this direction. In the past, most water control projects in America have aimed at special elements of control for particular usage; in relatively few cases has there been a general study of a water system with a view to securing the greatest total public benefits for all purposes.

The aim of planned utilization of water resources is to discover their full possibilities, to appraise their relative importance and value, to provide long-range unified plans for large areas and to supply guidance and control for their development, so that the various uses can be realized as fully as possible, can supplement and support each other as far as is feasible and will conflict with or neutralize each other as little as necessary.

During the past year there was ample evidence of the need of planned effort in the development and control of our water resources. The disastrous floods and loss of soil, to say nothing of the destruction to life and property, focused the public mind upon the conservation of our water and soil resources. The ravages of water out of control in the spring of 1936 cost the Northeast section of the United States hundreds of millions of dollars, many lives and untold suffering. The wasting of top soil from the lands of the nation produces a continuing loss estimated at $400,000,000 annually. These facts alone point to the fact that conservation is a national problem and one that should recognize neither partisanship nor state lines.

It is to this end, of course, that the great projects, Boulder Dam, the Columbia Basin projects and those in the Tennessee Valley are being developed. The Tennessee Valley Authority in particular represents an excellent example of a case in planning the unified development of a great river system for navigation, flood control and power development. It is possible to extend this type of planning to other great systems of America, to that instead of a great variety of conflicting developments there will be comprehensive and well-planned utilization of all water resources for all reasonable purposes.

The development of these projects, of course, would have little significance to us in the power industry, except as their cost affects general taxation, were it not for the fact that many of them are concerned with power production. Everybody knows that when water falls there is power in that water, power that men have used from time immemorial. So when T.V.A. lets water through these dams in pursuance of its constitutional functions with respect to flood control, navigation and irrigation, the question, as David Lilienthal[1] has pointed out, is not whether power should be developed—the power is there by virtue of the mere fact that the water is falling. The question is whether the power in that falling water shall be harnessed for the use of man or whether that power should be allowed to go to waste. Under any rational policy of planned conservation, it is unthinkable that this power should be wasted, since with a relatively small additional investment of equipment it can be harnessed and put to work.

Naturally where conflicting interests are involved, this matter can cause serious controversy and give rise to charges of injustice and false intentions on both sides, and this has been the case throughout the entire development of these projects. There has been much bitterness because of misunderstanding and a great

[1] Director, Tennessee Valley Authority

Thirty Per Cent of Power Used

A unique dam of frozen earth stopped a slide of 200,000 cu. yd. of earth in the east excavation of Grand Coulee Dam. Two refrigeration machines chilled brine which was circulated through 6 mi. of pipe embedded in the earth

Photo, Bureau of Reclamation

deal of injustice due to selfish personal or group interests. The entire history of the T.V.A. activities bristles with suits and injunctions—legal encounters which reflect little credit to the intelligence of the human race.

Despite legal battles, work on the large projects has gone forward steadily and in most instances is ahead of schedules. The first units at Boulder Dam are in operation. In the Tennessee Valley initial operation at Norris occurred late during the summer and Wheeler Dam is practically completed at the time of this writing; it probably will be in service before the end of the year.

At Bonneville on the Columbia, work has progressed rapidly and the generating equipment is now being delivered. This project involves two 66,000 hp. Kaplan turbines, the highest powered Kaplan units in the world. Work at Grand Coulee also is progressing rapidly and the first million cubic yards of concrete had been poured by the latter part of October. This project ultimately will develop 2,500,000 hp. but at present is being constructed only for irrigation purposes.

On the Loup River in Nebraska, two smaller power plants are nearing completion, the Monroe plant with 3200 hp. capacity and the Columbus plant with 18,000 hp. capacity. Both of these plants are scheduled for operation in the spring of 1937.

Not far from the Loup River projects, at North Platte, Nebr., the Platte Valley Public Service and Irrigation District in a new plant is installing 2—14,500 kv-a. units.

In the northeast, work on Passamaquoddy, the great tidal power project, has been halted through lack of appropriations but the work undoubtedly will be resumed sometime in the future.

These are the principal government hydroelectric developments in progress at the present time. Together they constitute the great bulk of all the hydroelectric development in this country, for in comparison to their combined capacity, the amount of private hydroelectric power being installed is small. At the present time the total installed hydroelectric capacity in this country is about 16,750,000 kw., this will be brought up to well beyond 17,000,000 kw. when the installations now in progress are completed. The amount of power generated by hydroelectric plants amounts to almost 40 per cent of the total power generated in this country.

Among the private hydro stations completed during the year, the automatic plant of the Idaho Power Company at Twin Falls, Idaho, is of distinct interest. This plant is situated 200 ft. below the rim of the 500 ft. rock canyon of the Snake River, sealed against flood and remotely controlled from the Shoshone Falls plant 4 miles downstream. Under the present head of 147 ft., the capacity of the plant is 9375 kv-a. but ultimately with a head of 179 ft. the capacity will be 13,500 kv-a.

At Lansing, Mich., an automatic station of 200 kw. capacity went into service in the fall of last year, and at Allegan, Mich., a 1700 kv-a. plant on the Kalamazoo River was completed and placed in service about the same time.

There were other installations on which data is

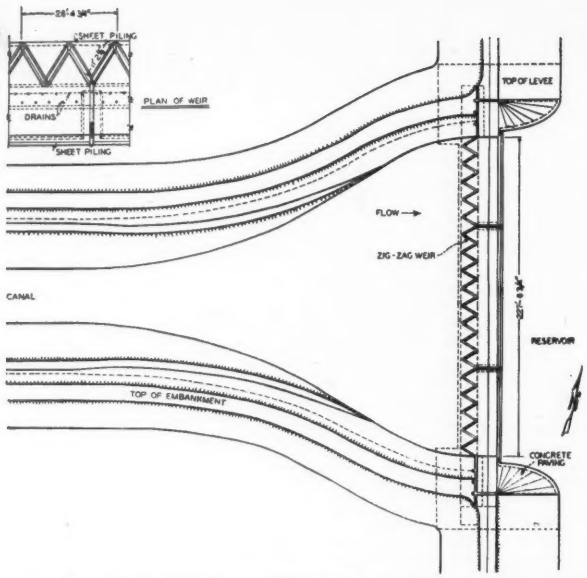


Fig. 2. Details of Zig-zag Weir on the Loup River Project

not available but this enumeration of the most important developments will serve to indicate the status of hydroelectric power in this country at this time. The bulk of the activity, of course, is in government or government-financed state or municipal projects but as the demand for electric power continues to grow, undoubtedly there will be more private activity in the near future. The most important matters in the hydroelectric field today are not concerned so much with technical and engineering consideration as they are with legal and constitutional restrictions and obstacles. America needs comprehensive legislation both Federal and State for the unified development of its water resources. Division of authority among 48 states has led to a wide variety of strikingly different state water laws. Many truly national problems or regional problems cannot be met by the Federal government because of constitutional restrictions and yet are beyond the reach of the individual states. This implies neither nationalization of power resources or undue restriction to private enterprise but it does imply recognition of the principle that the water power resources should be developed to the greatest good of mankind.

So much for the general status of water power development. Now what about the technical advances?

Technical Developments

As implied above, the technical development of hydroelectric power has reached a high degree of perfection and the hydroelectric engineers seem to be able to solve almost any problem that comes their way. The many technical problems underlying such super-great projects as Boulder Dam, Bonneville, and Grand Coulee are disposed of with such apparent ease that those not intimately concerned with the development of such projects might be inclined to assume that difficulties or problems did not exist.

From the sheer standpoint of size, the Grand Coulee Dam involves problems in construction and handling of material that make even those of Boulder Dam seem small. Although not as high as Boulder Dam Grand Coulee is far larger in every other way and when completed will be the largest man-made structure in the world. It will tower 550 ft. above bedrock with a crest length of 4300 ft., tapering in diameter from 36 ft. at the top to 500 ft. at the base. It will be the only masonry structure in the world that exceeds in bulk the Great Pyramid of Egypt. The 11,200,000 cu. yd. of concrete entering into its construction will be 3½ times that contained in Boulder Dam. The following figures comparing the size of Coulee with Boulder Dam show the difference more effectively:

	Grand Coulee Dam	Boulder Dam
Height (feet)	550	730
Length of crest (feet)	4,300	1,180
Width at base (feet)	500	650
Width at top (feet)	36	45
Excavation (cu. yd.)	17,000,000	7,000,000
Mass concrete in dam (cu. yd.)	11,200,000	3,200,000
Total rated capacity (hp.)	2,520,000	1,835,000
Length of main reservoir (mi.)	151	115
Average width (mi.)	0.8	2
Average annual run-off (ac. ft.)	79,000,000	15,000,000
Max. flow of river (sec. ft.)	725,000	300,000
Min. flow of river (sec. ft.)	17,000	2,300
Spillway capacity (sec. ft.)	1,000,000	400,000

While there are many interesting features about Grand Coulee, one of particular novelty concerns the placing of the concrete in the dam. This is distributed by means of a high distribution crane running on a steel trestle along the center line of the dam. As the concrete is built up around the footings of this trestle, the entire steel structure is being gradually absorbed into the dam to serve as reinforcement. It saves the work of dismantling the structure and strengthens the dam.

The resourcefulness of the government engineers working at Grand Coulee was amply demonstrated in their handling of a difficult situation caused by an earth slide which threatened to undo the excavation work as far as it had been completed. This slide involved 200,000 cu. yd. of earth, material which overlaid the rock and which was comparatively stable when dry and undisturbed but which due to the excavation started to flow into the cuts. Flowing at the rate of two feet per hour, this threatened to greatly increase the amount of excavation necessary. So the engineers decided to freeze it into immobility.

Two refrigeration machines were bought, second hand, with a total capacity of about 80 tons a day. About six miles of pipe was driven into the sliding mass in the form of an arch at the head of the gulch. Brine was forced through these pipes at a low temperature and the earth froze, thus creating a frozen dam 105 ft. long, 25 ft. thick at the base and 40 ft. high. This successfully stopped the slide. Construction of this frozen earth dam and its operation cost about $30,000, but it saved many times that amount.

At Bonneville, the important feature of interest to power engineers is the record size of the Kaplan turbines being installed. Rated at 66,000 hp. each, these units will be the highest powered Kaplan wheels in the world, being 50 per cent greater in capacity than the 42,500 hp. machines at Safe Harbor plant on the Susquehanna River.

The highest powered, fixed blade, propeller type turbines in the world are those installed at Wheeler Dam. Two of eight ultimate 45,000 hp. units are now installed. Although these first units are of the fixed blade propeller type, provision has been made in the power plant super-structure to install Kaplan units in the future if desired.

With units using large runners of this type, trouble is likely to be encountered from pitting and vibration due to cavitation unless they are set low enough to maintain pressure in the runner above the vapor pressure of the water. Accordingly, extensive tests were made on a model runner to determine the location which would give a safe margin above the cavitation limit. These tests indicated that installed position of the runners, their center lines 6 ft. below normal tailwater level and 13 ft. below maximum tailwater elevation would give a safe margin above the cavitation limit.

Some unusual problems were encountered in the construction of the Loup River project and the methods employed in their solution form a distinct contribution to hydroelectric practice. The Loup River project involves the use of a canal 35 miles long by means of which water is diverted from the Loup River at a point below Genoa, Nebr., and turned back into the river at a point near Columbus, Nebr.[1] This canal is an open ditch about 90 ft. wide at the water surface and varying from 28 to 60 ft. at the bottom and carrying a stream of water from 12 to 20 ft. deep, flowing at the rate of 1.8 mi. per hr., the grade being 4 in. per mile.

Two power plants are located on this canal, one near the town of Monroe where a fall of 32 ft. is utilized and the other at a point just above Columbus. At Columbus, the drop is 112.5 ft. Provision is made for only one reservoir which is located just above the Columbus Power House, the Monroe plant being designed to operate as a run of stream plant with the water level controlled at the head gates and the units automatically cutting in and out as the load demands. The Monroe plant will be remote controlled from the Columbus plant.

Because of the character of the soil, exceptional precautions were necessary to prevent erosion. An extremely low water velocity through the canal is maintained, never over 2¼ sec. ft. Provision for desilting the water at the intake to the canal also was made in the construction of a desilting basin, some three miles long. The water velocity in this basin is reduced to about 0.4 sec. ft. A dredge permanently floated in this basin will remove the deposited silt to keep the basin clear.

A novel feature of the project is a zig-zag concrete weir at the entrance to the reservoir which maintains the level of the water in the tailrace of the Monroe plant. By the zig-zag pattern shown in Fig. 2 a much greater effective weir length is obtained within a given width than with the ordinary straight weir. This effects a considerable saving in expense for foundations.

Another element of interest is the use of water rheostats at the Columbus plant to absorb the output of the generators there as the load drops off. There is no by-pass around this plant, hence in order to maintain the flow through the plant when the electrical load drops off, the current is diverted into the water rheostats. The turbines, therefore, continue to operate at normal speed and pass the same quantity of water.

The small plant at North Lansing, Mich., referred to in a preceding paragraph, deserves mention here because of the novel type of gates used in the dam. These gates, shown in Fig. 3, are buoyant and so balanced that they drop automatically as the water flows over them so as to maintain a constant pond level. The front of the gate is a flat plate, and the back an arc, the center of which forms the pivot point for the gate. The upper part of the gate is sealed off to form a buoyant chamber. Head water pressure is introduced into the chamber under the gate and the moments are so calculated that as the water breaks over the crest of the dam, the gate will sink sufficiently to maintain the pond level constant. By controlling the pressure under the gates the crest may be set at any desired level between the operating limits.

Much knowledge has been gained through the use of models. Of particular interest in this connection were the slow motion picture analyses of flow in transparent plastic models of the draft tubes for the adjustable blade turbines at Bonneville. These models were made of transparent pyralin which facilitated observation of hydraulic flows resulting from various load conditions on the model turbine. By means of these transparent models and the use of slow motion pictures, it was possible to determine the ultimate possible efficiency.

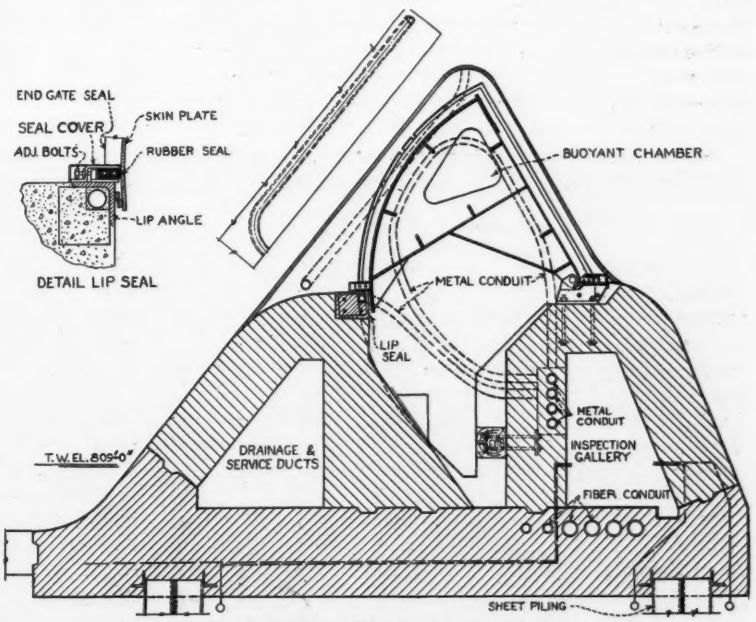


Fig. 3. Details of Floating Gate at Lansing

[1]See pp. 542-544 September issue, Power Plant Engineering.

A.S.M.E. Meets For The

COMPLICATED as the Annual Meeting of the American Society of Mechanical Engineers always is with simultaneous technical sessions, general sessions, special committee meetings and meetings where codes are discussed, one wonders that there are sufficient engineers with knowledge and experience to carry on discussions, to say nothing of attendance at social events and inspection tours. With the large attendance, however, nearly 2000, there was no lack of scientists, technicians and specialists for the presentation of papers and to carry on lively discussions at the Fifty-seventh Annual meeting held in New York City, November 30 to December 4.

In Commemoration of Westinghouse

With a program of anecdotes, words of praise and recollections of historical events arranged by Charles F. Scott, former associate of George Westinghouse conducted a ceremonial session of the Society to commemorate his ninetieth birthday on Tuesday afternoon, Dec. 1. Here fifteen men, intimately associated with the engineering achievements of Westinghouse, related personal experiences with this great engineer during the development of the air brake, alternating current, steam turbine, railway electrification and industrial organizations, dealing with these achievements as performing some new and useful function for the advancement of civilization and the human race. In each field, it was pointed out, he was a creative pioneer.

In addition, the Society designated President James R. Angell of Yale University as the 1936 Towne Lecturer, who on the Honors Night program, Dec. 1, spoke on the "Achievements of Westinghouse as Factors in Our Modern Life." Following this lecture another address on the subject "Westinghouse, the Man" was delivered by Paul D. Cravath, who served with Mr. Westinghouse on the Board of Patent Control.

As far as the public was concerned, Dr. Angell said, the air brake "easily" stood first. "While their implications extend quite beyond this zone, it is clear that Mr. Westinghouse's interests were first directed to problems of transportation, of people of freight or of power and that throughout his life all of his accomplishments had direct or indirect relation to issues of that character."

Mr. Cravath spoke of Westinghouse as a vigorous and unselfish leader whose every enterprise was essentially sound and strong. "Those foundations have proved able to carry the enormous structures that only his vision was able to foresee. It is a sad commentary on the limitations of human wisdom that the full fruition of Mr. Westinghouse's plans as an organizer came only after his death."

Officers Announced, Honors Conferred

As a result of the ballot Secretary C. E. Davies announced the following new officers: President, James H. Herron, James H. Herron Co., Cleveland, Ohio; Vice-Presidents, James A. Hall, Brown University, Providence, R. I., whose recent death leaves a vacancy to be filled; R. J. S. Pigott, Gulf Research & Development Corp., Pittsburgh, Pa.; James M. Todd, New Orleans, La.; Managers, Edward W. Burbank, Allis Chalmers Mfg. Co., Dallas, Texas; Kenneth H. Condit, New York, N. Y.; and Samuel W. Dudley, Yale University, New Haven, Conn.

Always impressive is the ceremony conducted by the Society in the conferring of A.S.M.E. awards. Each recipient was presented to President William L. Batt with reasons for conferring the honor, by a member of the committee responsible for the selection. This year the awards were as follows: Honorary Membership: To Geo. A. Orrok for his outstanding contributions to the engineering profession in the power field. A.S.M.E. medal: To Edward Bausch, Bausch and Lomb Optical Co., Rochester, N. Y., for meritorious mechanical de-

Gano Dunn presents the Hoover medal to Ambrose Swasey, "The Knight of the Kindly Heart," in the presence of Herbert C. Hoover

57th. Time

velopment in the field of optics. Worcester Reed Warner Medal: To Professor Charles M. Allen, Worcester Polytechnic Institute, Worcester, Mass., for his early and continued hydraulic laboratory work and for the permanent value of the papers on his development of methods of testing large hydraulic turbine installations. Melville Medal: To H. A. Stevens Howarth, Kingsbury Machine Works, Inc., Philadelphia, Pa., for his paper, The Loading and Friction of Thrust and Journal Bearings with Perfect Lubrication. Junior Award: To Harwood F. Mulliken, Jr., New York, N. Y., for his paper Evaluation of Effective Radiant Heating Surface and Application of the Stefen-Boltzman Law to Heat Absorption in Boiler Furnaces. Undergraduate Student Award: To Leon B. Stinson of the Oklahoma A. & M. College, for his paper on Polymerized Motor Fuels; Their Economic Significance.

Dinner to Ambrose Swasey

Outstanding among the events at every Annual Meeting of the Society is the annual dinner night. This year it held especial significance since in addition to the presence of Ambrose Swasey, the guest of honor to whom the Hoover Gold Medal was presented, the Society was favored by the attendance of Herbert C. Hoover, the first and only other recipient of this medal, which is awarded to an engineer who has performed outstanding public service outside the practice of his profession.

At the dinner in the Hotel Astor, with President William L. Batt acting as toastmaster, the presentation speech was made by Gano Dunn, Chairman of the Hoover Medal Board and an address was given by Honorable Herbert C. Hoover followed by the Thurston Lecture and Ambrose Swasey Eulogium delivered by Dr. Harlow Sharpley, director of the Harvard Observatory, on the subject Ninety Years of Stellar Exploration.

Dr. Swasey, despite his age, lacking only a few days of ninety years, was delighted by the receipt of the medal and appropriately expressed his appreciation. Of Mr. Swasey, the program stated in part: "Mr. Swasey represents the Yankee mechanic brought to its fairest flower and fullest fruit. In a machine shop in Exeter, New Hampshire, he first disciplined his native skill in precise and resourceful craftsmanship. Here he met his partner of mature years, Worcester Reed Warner, with whom, in 1869 he went to Hartford, Conn., where he completed the period of his life during which he labored under the direction of others and from which he departed with Warner in 1880 to form a long and fruitful partnership, the Warner and Swasey Co., of Cleveland, Ohio.

"Into the products of this partnership, machine tools and the structural parts of astronomical instruments, including many of the world's finest and largest telescopes, was put the ingenuity of correct design, the precision of skilled craftsmanship and the practicability of every day use that have made and sustained the reputations of the famous founders.

"As technical success and material prosperity crowned honest and intelligent labor, Mr. Swasey extended his influence and personality into a long line of distinguished services to the industry in which he worked, to engineering, to science, to research, to his church, to education, and to public affairs."

Gano Dunn, in the presentation of the medal, stressed those qualifications of an engineer for which the medal is awarded:

"There have always been in the engineering profession men of high standards who have felt the duty of relating their daily work to the public welfare; but the sense of duty of the profession as a whole to the public welfare is born of a relatively new and developing consciousness among its members.

"The creation of the American Engineering Council in Washington to represent the engineering societies in relation to the affairs of government, is proof of the desire of the profession to play its part as a whole in public affairs. On the other hand, the establishment by the American Society of Mechanical Engineers in 1929 of the Hoover Medal proposed and perpetually endowed by Conrad N. Lauer of Philadelphia, and jointly awarded by a board of representatives of the National Engineering Societies, is proof of the desire to give distinguished honor to those individual members of the profession who, by their services to the public outside and beyond their professional duties set a standard of leadership which all engineers admire and in increasing numbers are resolved to follow.

"It is individual services that the Hoover Medal was established to recognize; particularly those rendered extra to the ordinary compensation of engineers, at personal sacrifice and effort, and in devotion to humanity itself.

"From all their number, their representatives con-

stituting the Hoover Medal Board of Award have singled out Ambrose Swasey as worthy to represent their ideals of public service and as worthy to be held up for all time as an example of the type of engineer the Hoover Medal was established to honor.

"Swasey has never held a government position. As a mechanical engineer, his field kept him near home. He won his spurs in the precision workshop rather than in the wilds of distant climes. His benefits to great masses of people have been indirect rather than direct. Throughout his whole career, however, there has shown in his heart love of his fellow men which has been the inspiration of a lifetime of public service outside of his work as an engineer.

"Ambrose Swasey gave, in 1914, a large part of his remaining fortune, over half a million dollars, to the National Engineering Societies collectively for 'the furtherance of research in science and engineering or the advancement in any other manner of the profession of engineering or the good of mankind,' thus founding the first public service institution in the engineering profession.

James H. Herron

"His years are many, but his spirit constitutes an example to his fellows who hold him in personal affection no less highly than they held him in honor. It is not an accident that he has long been known as 'The Knight of the Kindly Heart.'"

In commenting on the work of Dr. Swasey, Mr. Hoover took the opportunity to point to a service engineers can render to the public at the present time. He said in part:

"The world probably believes mostly yet, at least it did up till recently, that invention is the product of some genius in a garret, but we know, that invention is the result of patient research, of long experiment and of minute improvement in building up of tools as well as the product, but there is very little drama about the tool.

"Most of us believe that our social system must be maintained in its vital and essential principles if human progress is to continue. But the problems which confront us today are indeed the problems created by engineers themselves.

"New problems of public service come now into the field of the engineer. With the general rise of engineers to executive position, the dependence upon engineers for clarity of thinking and planning, provision of works and enormous public services, we have to front the fact that these problems, which lie indeed even outside of government, must find their solution through engineering minds. We not only have the new problems of human relationship which the expansion of mass production and industry have brought upon us, but we have problems of industrial statesmanship in the conduct of these enterprises, which now involve the fate of civilization if we fail to find their solution, and they are problems that can be solved only by the processes of engineers. The painstaking collection of fact, of experiments, the determination of proportional weight of factor and experience, and, above all, the intellectual honesty that confronts the end.

"For the whole of a century engineers have been called upon to defend this action of the labor-saving device against the charge that it produces unemployment and human misery.

"I scarcely need to state the economic answer to that. New inventions and new articles increase the demand, increase the standard of living and of employment and we know from a thousand experiences that in the older articles of production, through cheapening the costs we decrease the price and expand the consumption, and thereby increase the standard of employment and, coincidently increase the standard of living. That is sound economics but it depends upon the time element and in the main the increase of employment under the standard of living depends also on reducing the price of goods to the consumer and here is where the engineer must range in the area of economics.

"If increased wages and profits are to absorb the savings which the engineer produces through his labor-saving devices and new methods, so that there is no reduction of price, which is essential to increasing consumption, we are thereby, by our own neglect producing a mass of technological unemployment; increasing prices merely because there is rising demand defeats the very end which statesmanship requires in our industries at this time."

Technical Work of the Society

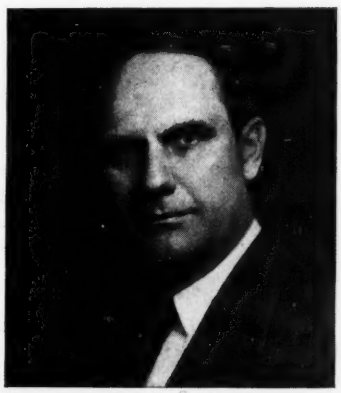
All day and evening for four days the hours were filled with interest for every mechanical engineer, whatever his specialty. The Society has a wide range of interests and its members have shown an extremely cooperative spirit. In the matter of research, for example, subjects under discussion by special committees covered properties, working and testing of metals; flow nozzles; generation, metering and condensation of steam; methods of lubrication. Such research studied will yield information of scientific and commercial value to men in the profession, the benefits of which nobody can estimate.

Results of research provide bases for the development of mechanical equipment and here the designers find need for standards on tolerances, cutting and forming tools, forms and fits, surface qualities, piping systems and fittings and fluid handling, as discussed in various committee meetings. Engineers recognize that performances of equipment must be compared fairly and to determine what is fair the Society has established test code committees, which held meetings on pumps, steam turbines, hydraulic prime movers, dust separating apparatus, stationary steam generating units and fans.

From such committees come much of the technical data presented to the Society and largely through their work the Society has developed to its present high standing. Formal papers report the more spectacular accomplishments of engineering and broaden the field of discussion. Thus the activities of the Society extend from the very inception of an engineering principle through research and manufacture to the practical applications of mechanical engineering.

Steamotive

One of the most important developments in the steam generating field, which may well be characterized as revolutionary, is a complete steam generating unit, given the name of Steamotive by its manufacturers, treated in a paper by E. G. Bailey, of Babcock & Wilcox Co., A. R. Smith, of General Electric Co.,



William L. Batt

and P. S. Dickey, of the Bailey Meter Co. It was stated that studies made some few years ago indicated that there should be a good field of application for small steam generating units of good efficiency, relatively light weight and small space requirements in the field of power generating equipment for installations of small and moderate capacity, say from 1000 hp. to 10,000 hp. In order to compete with other prime movers in this field, the steam should be generated at high pressure and temperature and, in order to reduce the operating expense, it was agreed that fully automatic control of the steam generation in response to changes in demand would be a desirable feature. Need of improved power for locomotives and similar applications was realized by the General Electric Co. and with the early work done by the Babcock & Wilcox Co. and Bailey Meter Co. on high-pressure, small-capacity boilers, as exemplified by the Bayonne and Purdue experimental installations, these three companies were brought together in the development of a boiler for applications to portable steam units in railway work.

Objects to be obtained were as follows: High steam pressure and temperature; minimum weight and size per unit of steam produced; wide range of capacity with ability of the unit to respond quickly to wide variations in load conditions; adaptability to wide range of fuels; completely coördinated auxiliary; completely coördinated automatic control; units to be of simple design and to be constructed in sizes small enough to be portable.

The developmental Steamotive unit was assembled in the General Electric Works at Schenectady, N. Y., during the latter part of 1934. The Steamotive boiler was designed and built by the Babcock & Wilcox Co., of Barberton, Ohio. It was oil fired and designed for an output of 21,000 lb. of steam per hr. at a pressure of 1500 lb. and a temperature of 1050 deg. F., when leaving the superheater, later changed to 900 deg. F. These specifications conform to the requirements of a steam turbine electric locomotive. This Steamotive unit is now in commercial service in the Lynn Works of the General Electric Co.

In the paper, various details of the boiler were fully described, as were also test results and proposed future developments.

It is possible to fit this type of forced-circulation boiler into a restricted space and the design is flexible in its adaptability to limits in height, width and length.

Replacement of refractory in the furnace and boiler setting by water walls and insulating blocks not only results in a large saving in weight and volume but also in reduced heat storage capacity that materially affects the ability to change output quickly. The small water content of the forced circulation boiler results in quick response to load changes and insures safety in spite of the high temperature and high pressure steam conditions. These factors permit quick starting from a cold condition requiring less than ten minutes from lighting the burner to full output.

It has been found that combustion liberation rates up to 400,000 B.t.u. per cu. ft. per hr. can be obtained with low excess air and smokeless combustion with oil fuel.

E. B. Powell expressed his opinion that the Steamotive gives promise of valuable contributions to the larger field of power plant design, especially forced circulation of the boiler water with its associated steam separator and the use of exclusively forced draft.

"It seems entirely probable," he said, "that economic considerations will call for the use of operating pressures much higher than the 1400 lb. which for the past dozen years has been regarded as the temporary pressure limit for general commercial application in this country. With the adoption of such high pressure, control of circulation will assume greater importance and it will be of considerable advantage to have a local background of experience with forced circulation boilers, even though of relatively small dimensions and capacity. These higher pressures will also bring an accentuation of the steam separator problem, and experience with the Steamotive separator will doubtless throw light on this problem also."

Port Washington Plant

Attention of power engineers everywhere has been drawn to the Port Washington Plant of the Milwaukee Electric Railway & Light Co. because it has shown an operating record unequalled up to the present time by any other steam plant in the world. The unique design features and operating experiences of this plant were described in a paper by F. L. Dornbrook who has been in charge of operation since it was put into service. Design was based on experiences at the Lakeside Plant with such improvements as were justified by those experiences and by progress in the power

plant art. The principal improvements are the unit design and the use of a temperature of 825 deg. F. for both throttle and reheat steam. Selection was made of the unit design calling for an 80,000-kw. tandem compound turbine generator and a single 690,000 lb. per hr. bent tube type of boiler with a combination radiant and convection superheater and an all radiant reheater, with only one set of auxiliaries which made possible important investment and operating savings.

For the first 10½ months that the plant was in operation, the outages experienced were for the most part due to load conditions rather than operating difficulties. The boiler and turbine have performed with equally high reliability. In spite of widely fluctuating loads, the superheat and reheat temperatures at the turbine have remained unusually uniform to the benefit of both reliability and efficiency. Both long and short operating periods have been experienced so that a fair test of all operating conditions has been obtained. A table summarized monthly averages of daily data to aid in economical operation, unit design assisting greatly in simplifying thermal accounting. From data obtained it was shown that 10,900 B.t.u. per kw-hr. net is about the ultimate economy level. It was also shown that heat consumption from the day of starting, including coal for boiling out to prepare the boiler for operation, averaged 11,220 B.t.u. per net kw-hr. or 30.5 per cent over-all thermal efficiency.

The paper dealt with the operating flexibility, steam temperature regulation, continuity of service, equipment performance, and concluded with the statement that experience indicates that the plant is reliable, easily operated and economical. Its initial cost is slightly less than all previous installations in service on the system and its operating costs to date have about two-thirds those of the Lakeside Station.

Surface Condenser Tests

Tests of a 50,000 sq. ft. surface condenser at widely varying temperatures, velocities of inlet water, and loads were described by G. H. Van Hengel of the Detroit Edison Co. These tests were conducted to obtain a better understanding of the undercooling of condensate and of the heat transfer coefficient. The author replaces the heat transfer coefficient with a simplified form of the reciprocal of the heat transfer coefficient; namely, the local resistivity taken at the cooling water inlet end of the condenser.

Exhaustive tests on a modern condenser show first that superheating of the condensate as generally defined is possible, if provision is made for the recovery of the velocity energy of the steam flowing into the condenser; and second, that a particular correlation exists between the resistivity at the cooling water entrance end of the condenser and the Reynolds number of the cooling water at the turbine entrance.

An analysis has clarified two points: First, the superheating of the condensate is due to the partial recovery as pressure of the velocity energy of the steam at the exit of the last wheel of the turbine. It is shown that the condenser neck wall pressure on which this superheating of the condensate is based is not the correct one to use. Instead the static pressure plus velocity pressure at the condenser neck or any other chosen point should be used. Second, the confusion regarding the heat transfer coefficient was explained by the fact that the logarithmic mean temperature difference as generally adopted is true only for a single spot in the condenser and is not applicable for the overall heat transfer, due to the wide variation of temperature of both steam and water throughout the condenser.

Turbine Instruments

Superposed turbine regulation problems were considered in a paper by A. F. Schwendner and A. A. Luoma, both of the Westinghouse Electric & Mfg. Co., which gave a description of the hydraulic governing system used on Westinghouse superposed turbines. It attacked from a theoretical standpoint some of the governing problems encountered on superposed turbines, such as stable synchronizing and stable operation on the line with an exhaust pressure regulator in action.

Turbine supervisory instruments and records were dealt with in a paper by J. L. Roberts and C. D. Greentree of Schenectady, N. Y., which described a set of instruments for the electrical measurement and detection of such mechanical quantities as shaft eccentricity, bearing vibration, shell expansion and interference or rubbing of rotary parts. It also contained an analysis of typical as well as special starting and loading sequence records taken on a 160,000-kw. steam and a 20,000-kw. mercury vapor turbine generator and the paper concluded with opinions as to the adaptability of instruments of this sort to turbine operation.

Supervising instruments for the 165,000-kw. turbine at the Richmond Station were discussed by H. Steen-Johnsen, of the Westinghouse Electric & Mfg. Co. This installation consists of electrical instruments to measure such turbine characteristics as vibration, spindle eccentricity, cylinder expansion and noises. The equipment has been in operation for one year and during this time the vibrometers and expansion meters have proved to be useful during starting as well as normal operating periods. The eccentricity meter, although of no great value on a machine equipped with a spindle turning device, has revealed interesting facts about the movement of the journals in the bearings. The noise meter transmits the noise characteristics as heard with a listening rod to a central location on the gage board. The instrument has been found unsatisfactory because of the great number of noises heard in a machine of this size, making it difficult to detect a rub whether a listening rod or other means is used for the purpose.

C. Richard Soderberg stated that these instruments reveal typical behavior of turbines not previously recorded in this manner. The importance of the starting gear in this connection is superlative. Use of supervisory instruments is, in his opinion, justified on very large units.

Undercooling in Steam Nozzles was discussed in a paper by J. T. Rettaliata of Johns Hopkins University dealing primarily with the effect of wall roughness on the flow of steam in nozzles and secondarily with the drop growth and the occurrence of initial condensation. It was found that roughness of the nozzle walls caused a retardation of steam flow and resulted in the Wilson line's occurring at the 3.2 per cent moisture

line on the Mollier diagram instead of at the 3.7 per cent moisture line as was found for a nozzle with smooth walls.

In a specially designed nozzle, drop growth was accomplished as evidenced by the complete visible spectrum which resulted from the scattering of light by the expanding steam in this nozzle. Photographs of the condensation region show that condensation is not occurring at any point previous to where the eye sees it. These researches indicate that the location of the Wilson line on the Mollier diagram depends entirely upon the rate of change of velocity of the steam and, therefore, cannot be fixed for all conditions. In accordance with this fact, the author suggested that the term "Wilson line" should be replaced by the more appropriate one of "Wilson zone."

Collection and evaluation of data for the design of steam-generating units was given consideration by B. J. Cross of the Combustion Engineering Co., who pointed out that rational progress in the development of steam-generating units can be made by careful deductions from known facts about such units, and by extrapolation of actual operating data. The paper related some of the difficulties encountered, and the care necessary in making field measurements in obtaining such operating data.

History of the Steam Turbine

Each of three papers took up the story from the angle of a different company, the Westinghouse article being presented by Emil E. Keller and Francis Hodgkinson, the Allis-Chalmers article by Professor A. G. Christie of Johns Hopkins University and the General Electric article by Ernest L. Robinson. Like so many pioneers to America, these turbine ancestors came from Europe in the form of patented ideas representing the developments respectively of Parsons, Zoelly and Curtis, and American genius was put to work modifying and improving the details of construction until today little resemblance to the original stock exists.

Supercharging of Internal Combustion Engines

Use of blowers driven by exhaust-gas turbines was given consideration in a paper by Alfred J. Buchi of Winterthur, Switzerland, which discussed the use of such turboblowers for supercharging internal combustion engines and scavenging the cylinders, and also the principles on which the blowers are designed. He presented indicator, temperature and entropy diagrams for Diesel engines equipped with the blowers and gave results of tests conducted on the blowers. A number of internal combustion engines with exhaust-gas turboblowers as used in different types of service were described in the paper. The author also presented a number of curves showing the scavenging effect of the blowers and the brake mean effective pressure, brake horsepower and fuel consumption obtained on engines using the Buchi system of turbo charging.

In a coal-cleaning symposium, G. L. Arms of the Jeffrey Mfg. Co., gave as the first paper a description of coal washing and the Baum jig, the problems encountered during the preparation of coal by jigs, development of the Baum jig since its introduction in the United States and the operating principles and construction details of the latest design.

In the second paper, Thomas Fraser of Stephens-Adamson Mfg. Co. described coal preparation by the air-sand process for the preparation of coal by specific gravity separation, where the float-and-sink separation is made in an artificial dry liquid medium of sand and air that can be adjusted within certain limits to the specific gravity needed to give a satisfactory coal product. This dry float medium of sand and air is produced by passing a continuous flow of air bubbles upward through a bed of dry sand in a separator box.

John Griffin of the American Rhoelaveur Co. presented the third paper which dealt with the Rhoelaveur coal cleaning process and explained its operating principles. He submitted data giving the variability of raw coal from Illinois and Pittsburgh seams and the uniformity of the clean coal produced in the Rhoelaveur plants.

Ash and Cinder Catching

Here ten different authors contributed short papers, covering public nuisance and damage from fly ash; construction and performance of the Cottrell precipitator; the Modave washer as a means of preventing the escape of fly ash and cinders; performance of a cinder vane fan; and the Prat-Daniel cyclone as a means of eliminating fly ash. J. R. James spoke of the commercial uses of fly ash, in the making of concrete building blocks used in foundations of buildings. Other features treated were performance of gas washers at the Hell Gate plant, the Pease Anthony scrubber, the Buell cyclone and the testing of cinder and fly ash catchers.

Metallurgical Studies

Physical-Property Uniformity in Valve-Body Steel Castings was discussed by A. E. White of the University of Michigan, C. L. Clark of the University of Michigan, and Sabin Crocker of the Detroit Edison Co., giving a description of the investigation of the physical properties of specimens cut from various sections of large welding-end valve bodies made of carbon-molybdenum cast steel, the results indicating that the welding ends are the soundest part of the valve body.

Evidence of rather general porosity was disclosed by the microsections from the thicker wall portions of the bodies and in the bonnet flange with consequent low ductility values for some of the tensile specimens from these locations. While this condition was considered fairly acceptable when allowance was made for greater metal thickness in these sections, the investigation showed these to be the regions where improvements could be effected through further development of casting procedure.

Air Flow Measurement

Square-edged inlet and discharge orifices for measuring air volumes in the testing of fans and blowers were discussed by Lionel S. Marks, giving the results of investigations on a simplified form of square-edged orifice. Discharge coefficients obtained are identical with those found in extensive German tests adopted by the International Standards Association. This agreement justifies the use of the coefficients for large size ducts and the variety of velocity distribution found in the fan discharge ducts.

National Exposition of Power and Mechanical Engineering

FOR THE twelfth time, the National Exposition of Power and Mechanical Engineering was held in the Grand Central Palace during the week beginning November 30. Each time the Exposition has brought to the front some new equipment, the application of new principles to industrial uses or improved designs of thoroughly tried out equipment. This year, while a few of the exhibitors had entirely new products to show, the great majority took the occasion to point out improvements in the details of design and construction of their products and betterments made by the choice of some of the newer alloys.

Throughout the entire period of the Exposition the attendance was much improved over that of two years ago and there was evidence, on the part of visitors, of a desire to investigate and compare the merits of products with the idea of putting them to use, in contrast to the curious minded visitors so often predominating at expositions of this kind. Among the exhibitors a general expression was that of satisfaction with the results already obtained and the prospects of further business to come in the next few months. Some idea of the extent and character of the Exposition may be gained from the following comments on some of the important exhibitors.

Instruments

During recent years the importance of instruments in the operation of power plants has been receiving greater recognition, not alone because engineers have learned to use them more extensively but because the instruments themselves have been greatly improved in accuracy and reliability and their functions have been greatly extended. In this field the Bailey Meter Co. has always taken a leading part, and its exhibit of a complete combustion control system showed a number of notable improvements that have been made. Its boiler meters, multiple point gages, recorders, feedwater control, smoke density recorders and fluid meters which were given consideration have all been kept abreast of the times in design and choice of materials.

Products of the Bristol Co. on display included indicating controllers, thermometer controls, Pyromaster potentiometers, recorder controllers, multiple recorders, modulated controllers, electric flow meters, pyrometer controllers and indicating pyrometers.

As a development leading to greater accuracy in the mixing of quantities of solids and liquids, Builders Iron Foundry had a proportioning device operating in its booth by means of which dry materials

weighed on a Toledo belt scale are proportioned to liquids measured by flow meters manufactured by the company in such a way that any desired proportion of liquid and dry material may be secured. This device goes under the trade name of Chronoflow meter.

Recording and control instruments of the Brown-Minneapolis-Honeywell line were shown at the booth of the Brown Instrument Co. Included in this exhibit were the draft or over-fire pressure controller, which is essentially an indicating draft gage equipped with an Air-O-Line control system, a new instrument for controlling wet and dry bulb temperatures, a new combined pyrometer and multiple point switch for determining the exhaust temperatures of Diesel engines, and a new Protectoglo combustion safeguard system. The exhibit also included some of the older line of instruments such as CO_2 meters, flow meters, level indicators, control instruments, and the electrical and pneumatically operated valves.

Flow meters and steam specialties were shown by Cochrane Corp. but a special feature was made of the Cochrane deaerating hot process water softener which combines in one apparatus the three functions of softening, heating and deaeration.

Mathematical instruments are not new but the Foxboro Co. has developed an integrating flow meter which will calculate the total flow and indicate the reading directly. The company's complete line of instruments including temperature recorders, recording gages, flow meters, potentiometer recorders and controllers, stabilog and Rotex controllers and various types of control valves were prominently displayed.

Just a trifling pressure of air is required for the operation of a boiler furnace and the Hays Corp. has developed and improved its full line of draft measuring instruments from the simplest U-tube manometer to the sensitive draft recorder used for precision testing as aids to furnace operation. CO_2 recorders were also exhibited and the workings of the Carrick combustion control system, manufactured by the Carrick Engineering Co., were explained to visitors at this booth.

During recent years much more attention has been paid to measuring and control equipment in the power plant than was previously the case. One of the companies contributing largely to this art is Leeds & Northrup Co., which had on display a number of null-balance instruments which help both to reduce power costs and to insure continuity of power service. A representative selection of instruments for measurement and control in connection with steam and other mechanical power generating equipment for electrical generation and electrical distributing systems and for general testing were on display in operation. Among these instruments were the Centrimax flow meter, Micromax CO_2 recorder, Metermax combustion control, and the Silver Anniversary Micromax control.

Particular attention in the display of the Permutit Co. was paid to the water conditioning equipment which is used for industrial processes as well as for correcting feedwater impurities. Other power plant specialties displayed were flow meters, exhaust gas analyzers and recorders.

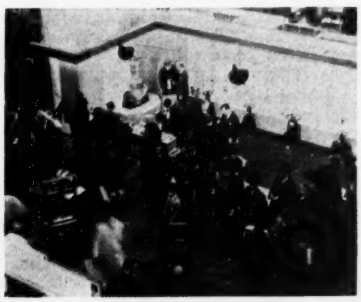
The Republic Flow Meters Co. had an attractive booth in which were explained the operating principles of the Smoot control for automatic regulation of combustion conditions in power boilers. Flow meters, CO_2 instruments, draft indicators, pressure instruments, temperature recorders and water level controls were also displayed.

Demonstrations of the use of Rotometer for indicating water flow in pipes were conducted by Schutte & Koerting Co., several of these instruments being in operation. This company also exhibited high pressure valves with welding ends in boiler stop and check designs.

To improve the readability of their thermometers, Taylor Instrument Cos. have developed their new Binoc tube with triple lens. This tubing used on thermometers reflects the light more strongly than ordinary tubing, improving visibility. Other features of the exhibit were thermometers of the indicating and recording type, especially adapted to industrial use.

Valves

Bright and shining and numerous were the valves on display. Each manufacturer presented valves considered best in choice of material, construction and workmanship to fulfill the service functions for which they were designed. For example, the Chapman Valve Mfg. Co. displayed a 12-in. gate valve designed for 1500 lb. steam pressure, 100 deg. F. temperature, operated by a Chapman motor unit, and also showed the working of a non-slam tilting disc check valve and a cone valve of novel design which may be either manually or power driven or controlled automatically to maintain a supply tank level.



Likewise the Crane Co. through its research in metallurgy has provided materials for the construction of its valves which suit them to all lines of industrial service. Whether the material handled be corrosive, the temperatures and pressures high, or the service conditions extreme, Crane valves, piping and fittings may be selected for the service. An attractive line of these was shown at this booth together with power driven valves and steam traps.

High pressure and high temperature valves for severe service have always occupied the attention of the Edward Valve & Mfg. Co. These are made of cast steel, forged steel or, for lower pressures, of Ferac. Exhibits were also made of non-return valves, blowoff valves, and feed line stop check valves.

Renewable valves which are easily repaired by replaceable seats and discs were featured by the Fairbanks Co. Another advantage of these valves is that packing in the stuffing boxes can be renewed while the valve is under pressure.

Valves for every purpose from small to large were given attention by Jenkins Bros. but special emphasis was laid on iron body gate valves and the solid wedge and double disc parallel seat types.

With high pressures becoming more common, Lunkenheimer Co. displayed a complete line of steel valves for modern power plants designed for pressures from 150 to 1500 lb. per sq. in. and fitted with both flange and welding ends.

Using new metals and new pipe fabrication methods, the William Powell Co. has redesigned and modernized its line of valves to fit them for the high temperature and high pressure conditions now common in power plants, also has provided them with welding ends.

A motor-driven, high-pressure steel valve was an attraction provided by Reading-Pratt & Cady Co. There were also on display iron and brass body valves for all types of industrial service.

High pressure valves and fittings made by Henry Vogt Machine Co. are of drop forged steel and the large units are provided with grease fittings for lubricating purposes. These valves are used extensively in power plants, on oil refinery equipment, and refrigerating machinery.

Valves and fittings of modern design that can be rapidly and accurately fabricated were the outstanding feature of the Walworth Co. display, which also included pipe tools and wrenches.

Pipe fitters and fabricators have been provided with new and more accurate equipment to do their work as was evidenced by the display of the Beaver Pipe Tools, Inc., showing the new designs of pipe threaders and cutters, hand tools and power-driven machines, some of which were in operation in the booth.

Other recently developed fabricating aids, made by Bonney Forge & Tool Works, are welding fittings which go under the trade name of Weldolets and Threadolets, and are used as outlets from boilers or headers.

Also progress along this line has been made by Grinnell Co. with its complete line of pipe fittings which are especially made for convenient and accurate fabrication. Standing out in the exhibit were a number of designs of pipe hangers and a particularly ingenuous Genspring.

Brass, Bronze and Copper

The conductivity and corrosion-resistant characteristics of copper and its alloys have brought this metal distinctively into the power plant field. Very appropriately, therefore, Bridgeport Brass Co. exhibited its line of condenser tubes, heat exchanger tubes, brass pipe and tubing. In the booth also was a device in operation which was used to test the corrosive effects of jets of aerated water upon samples of brass sheets. To resist this type of corrosion the Bridgeport aluminum bronze was especially recommended.

Condenser tubes constructed of 15 different alloys, each of which is chosen for a particular service were attractively displayed by Chase Brass & Copper Co. In addition to these, brass piping and fittings as well as electric cables were shown.

Anaconda fittings for every copper tube requirement were featured by the American Brass Co., one specialty being the solder type fittings in wrought copper or cast bronze. Condenser tubes and flexible metallic hose and tubing were also included.

Expansion joints which are constructed of copper and stainless steel and are of the direct flexing type were exhibited by E. B. Badger & Sons Co.

Electrical Equipment

At the booth of the Allis-Chalmers Mfg. Co. a feature of particular interest was the controlled power rectifier which uses some of the new principles for converting alternating into direct current. Other features of the exhibit were the Texrope drive using Texsteel sheave. The company also showed centrifugal pumps, turbine blades of the latest design, rotary air compressors, and gave out information on the Akon feedwater treatment, which is one of the newer products of the company.

Of special interest at the booth of General Electric Co. was the recently developed direct-acting generator voltage regulator which changes its resistance by a tilting motion and without the use of vibrative contacts. There was also an Alnico held-in contactor which remains closed with no current in the coil and without the use of latches, a product of recent development. In addition to these were the Tungar-bulb direct current arc welder, a three shoe solenoid brake, a Thrustor, a motor with a built-in disc brake, Pyronol capacitor, gear motor, fan cooled motor, circuit breakers, instruments, and an electric eye demonstration.

Steam Plant Specialties

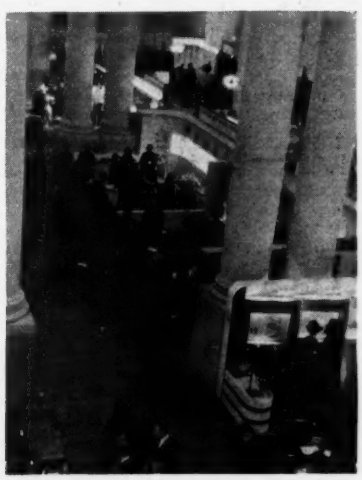
In the design of equipment for the power plant field great ingenuity has been shown in those specialties that make up the details of the plant and insure its smooth running. Steam traps, valves for specific purposes, regulating devices and safety appliances all have undergone improvements in the past two years that warranted many manufacturers in displaying their products coming under this class.

With a full line of traps on exhibit and a number with glass bodies in operation, the Armstrong Machine Works made it convenient to see the principles upon which its traps operate and the changes in details that have been made.

Anderson traps which go under the trade name of Silvertop have been modernized in design by the V. D. Anderson Co. and were displayed along with such instruments as well-type manometers and draft gages.

Automatic valve specialties, including pressure-reducing and regulating valves, and several types of valves for specific control purposes were featured by A. W. Cash Co. The Cash system of combustion control extensively used in power plants was also shown.

Employing forged steel, the Clees Valve & Engineering Co. has designed a new blowoff valve of tandem type, suitable for



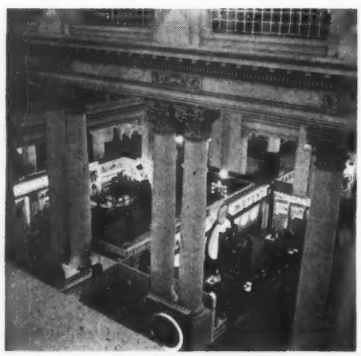
working pressures up to 1800 lb. In the same booth were products of the Atlas Valve Co. including such specialties as pressure regulating, float control and thermostatic control valves and damper regulators.

Safety valves, long known for their close control, low blowdown and permanent tightness were shown in latest designs by Crosby Steam Gage & Valve Co. Recording and indicating gages also made up part of the exhibit.

Among the newer specialties exhibited were the valves and separators manufactured by the Dri-Steam Valve Sales Corp. The separating mechanism is so compact that it may be employed in the construction

of valves so that steam delivered to process equipment is thoroughly dry at the point of delivery. These separators are used also in boiler drums and in steam line locations as well as gas or air lines where moisture must be removed.

With high pressure now common in the power plants of the country, the absolute necessity of safe auxiliaries has been recognized and among these are the products of the Ernst Water Column & Gauge Co. such as the high-pressure boiler gage glass, and the Ernst leakless gage columns. A feature of these columns appreciated by operating engineers is the easily read color indications which show the water level.



Duplex blowoff units for pressures ranging from 250 to 600 lb. were displayed by the Everlasting Valve Co. together with the company's emergency throttle shut-off valves.

Pressure and float control equipment were features in the booth of Kieley & Mueller Corp., where an extensive display of pressure regulating valves, back pressure valves, pilot reducing valves, liquid level controllers and steam separators was made.

Calling particular attention to its spray nozzles for air washing purposes, Monarch Mfg. Works, Inc., pointed out that these are built of brass in capacities from 4.7 g.p.h. up, at pressures of 40 lb. A line of valves and strainers was also shown.

Emphasizing its new Eye-Hye remote reading water level gage, Reliance Gauge Column Co. demonstrated how this brings the water gage reading down to the boiler room floor in the most convenient location for the boiler attendant, regardless of the corners which have to be turned or the girders and piping which must be avoided.

An interesting demonstration of how water can be blended from cold and hot sources was carried on in the booth of the Sarco Co., Inc., thus demonstrating the flow control equipment and methods which are products of this company. Also on display were steam traps and flow meters.

Steam specialties of the latest designs, including reducing valves, traps, pump governors, and boiler feedwater control, made up the exhibit of the C. E. Squires Co.

The Kleervu gage glass protector which is a product of Wright-Austin Co. was designed as a safety device for the protection of the operator in case of gage glass breakage and displayed here along with water columns, oil and steam separators, air separators and air traps.

Specializing as it has for many years in the manufacture of blowoff valves in both single and double arrangement, the Yarnall-Waring Co. attracted distinctive interest in its latest product, a forged steel tandem blowoff unit designed for 1500 lb. pressure and equipped with lubricated ball bearings. This, together with other designs of blowoff valves, water columns and gages, spray nozzles and hydraulic valves, formed the bulk of the exhibit. Also of interest was the impulse steam trap which operates on a newly applied principle and has many advantageous features.

Displaying an actual boiler breeching constructed in miniature, Connery Construction Co. explained that the expansion construction, a patented feature of this company, used for breechings, ducts and uptakes, prevents buckling, warping and collapse. These breechings are electrically welded, gas tight and moisture proof.

Boilers and Heat Exchangers

With advances made in the use of high pressure steam, industries as well as utility plants are taking advantage of the opportunities offered by the use of the newer cycles. Thus, more frequent calls are being made for heat exchangers and boiler requirements are growing more exacting. District heating is now carried on as a byproduct of many power plants and it was noted how the American District Steam Co. fitted its heating specialties such as the Adsco water heater, expansion joint, Banion tile conduit, and rotary condensation meter, together with condensation handling equipment, into this growing steam using field.

Unit heaters were on display in the booth of the Aerofin Corp. which is employing its products in the heating of factory space as well as many locations around power plants.

With dry steam an essential in the operation of steam generators, much attention was attracted to the operating model of the B. & W. steam scrubber in the booth of the Babcock & Wilcox Co. Here also were displayed a type B coal pulverizer, Bailey water-cooled furnace construction, and Seamless boiler tubes.

Equipment on display by the Carrier Corp. had to do with air conditioning, refrigeration and space heating which the company employ in its specialty of manufacturing weather.

An attractive display of photographs and colored drawings arranged by Combustion Engineering Co. illustrated C.E. steam generators, as designed for capacities from 1000 to 5000 lb. per hr., on up to 1,000,000 lb. per hr. The C.E.-Raymond bowl mill for pulverizing fuel was also shown in a large illustration.

Water walls, condensers, a new type of expansion joint with stainless steel bellows, intervane blowers for pulverized coal, a model marine steam generator and an axial flow fan made of Dowmetal drew attention in the booth of the Foster Wheeler Corp., which also displayed the Dowtherm vapor generator which gives 750 deg. F. temperature without high pressure.

Equipment used in heating plants was the center of attraction at the booth of the Nash Engineering Co. Here were exhibited compressors, vacuum pumps, the Jennings return line vacuum heating pump, and other specialties of the company's manufacture.

Refractories and Insulation

Use of carborundum for refractories and grinding material was featured by the Carborundum Co., calling particular attention to Carbofrax brick which is used as a lining for boiler furnaces along the clinker line.

Dura-Stix, a refractory cement, was the principal feature of the Keystone Refractories Co. which also displayed Kromo plastics, retort cements, Steel Veneer, and Boiler Patch, all of which are plastic cements suitable for application to boiler furnaces.

Packing and pipe insulation were shown by Ehret Magnesia Mfg. Co. The construction of the Durant system steam conduit interested many. This is a coated pipe specially insulated and protected by a metallic jacket, the whole pipe being designed to eliminate electrolysis, exterior corrosion and erosion and radiation of heat to the surrounding earth.

Asbestos products, displayed by Johns-Manville, included insulation for walls and piping, all types of mechanical packing and gaskets, and refractory material known as Firecrete, which is a hydraulic setting refractory cement handled like concrete.

Exhibits of asbestos packing, insulation and electrodes used in electric welding were displayed by Keasbey & Mattison Co.

At the Norton Co. booth where refractories, bricks and abrasives were displayed, it was stated that furnace walls made of Crystolon brick remain free from clinkers and slag even under severe operating conditions.

Special emphasis was given by Quigley Co., Inc., to its protective coating, insulblox, and to its refractory gun, which is used for the speedy application of cement in the repair of side walls, bridge walls, flues and baffles.

Combustion Equipment

Dust collectors and blowers drew attention to the booth of the American Blower Corp., particularly a unique demonstration of the principle of the Sirocco ST Dust collector.

Stokers for industrial, commercial heating plants, institutions and residences were on display by the Iron Fireman Mfg. Co. The newest development of the company is a furnace which has the coal delivered to it by pneumatic means. All of the company's fuel-burning products are automatically controlled and air supply is proportioned to give highest efficiency.

Thermix air heater and gas cooler was displayed by Prat-Daniel Corp., together with dust collectors, Thermix stack and draft fans.

Pumps and Packings

One of the new developments in the field is the Hydroseal pump, shown by Allen-Sherman-Hoff, which is constructed with Maximix rubber parts for the pumping of sand, slime, sludge and slurry. Another feature of the exhibit was the Hydrovac system of ash conveying, which removes dust from the last boiler pass, economizers, preheaters, precipitators, flues and stacks, or siftings from underfed stokers.

Along with a demonstration of its new gasket cutter designed for making gaskets of asbestos sheet, rubber, vegetable fibre, paper, cord and felt, The Allpax Co., Inc., also displayed industrial packings for all purposes and shredded metallic packing.

Mechanical packings and gaskets suitable for making seals against liquids in all kinds of industries and against pressures up to the highest now in service were displayed by Crandall Packing Co. For the first time a new design of rod packing was

shown which is built up from strands that are first lubricated and graphited separately, then braided to size and formed into lapping rings with angular sides that make the packing self-adjusting to the rod, these rings being separated by white metal retaining rings which help support and guide the rods as well as prevent the rings from becoming fast to each other.

Asbestos and metallic packings were products displayed by Crane Packing Co. Superseal No. 1 is the style which is recommended for general service such as water, air or gas where the temperature does not exceed 550 deg., while Superseal No. 6 is designed for temperatures around 1000 deg.

Apexior coating, made by the Dampney Co. of America, is used for the protection of metal, exposed to water, chemicals or gases. In boilers, it is said to prevent the chemical bonding of dirt or scale to the boiler metal, thus maintaining clean surfaces.

Clozure shaft packing, designed to retain lubricating oil within bearings or prevent the flow of liquids around rotating shafts is among the newer developments of Garlock Packing Co. Chevron packing, gaskets of many shapes and valve discs were also shown.

Among exhibitors of lubricants was Joseph Dixon Crucible Co. with its industrial paints and lubricants, Ticonderoga flake lubricating graphite and Microfyne flake graphite which because of its fineness is adapted to applications requiring highest purity in smallest particle size.

Texas Co., with samples of greases and oils for industrial uses, called particular attention to the lubricant it has available for use on Diesel engines which goes under the trade name of Texaco Algol or Ursa oils, refined from special crudes.

Tide Water Oil Co. presented a display of its complete line of industrial lubricants, including oils, greases, and special lubricants for every possible condition of temperature and bearing load.

An entirely new system of conveying granular and even liquid materials either horizontally, vertically or around pillars has been developed by the Johns Conveyor Corp. It consists essentially of two semicircular strips of rubber, each reinforced by a chain, to give it strength, and with the contacting edges tongued and grooved so that the conveyor resembles a fair sized rubber pipe, the diameters ranging from 2 to 12 in. One side of the conveyor is provided with rubber discs which prevent the flow of the material along the conveyor. At the feeding points, the sections of the conveyor are separated simply by passing abruptly over a specially designed pulley. The conveyor is again sealed and given a twist to hold it closed by pulleys as it leaves the feeding point and by a somewhat similar method discharge is affected at any desired point along the travel of the conveyor.

Results of research work which has been done with leather products were on display by Graton & Knight Co., which also demonstrated the pulling power of its belt by means of a motor-generator drive which gave visual evidence of the superior quality of its recently developed belt.

Mechanical, power transmission equipment, such as clutches, flexible couplings, silent chain drives, and free wheeling clutch were shown by Morse Chain Co.

Many of the advances made in industrial development during the past few years has been due to a better understanding of alloy metals and the contributions to this by the International Nickel Co. have been noteworthy. At its booth many of the Nickel steels were on exhibit and the uses of each of the special alloys were explained by attendants. Among those alloys are "A" Nickel, 99 per cent; manganese nickel, 94 per cent; Inconel, 80 per cent; Monel, 67 per cent; and other special alloys, down to nickel aluminum and nickel cast iron with one per cent nickel. These special metals are used extensively where corrosion resistance is essential.

Diesel Honored

COMMEMORATING the Fortieth Anniversary of the introduction of the Diesel engine to America, and honoring the genius of Dr. Rudolf Diesel, leaders of the industry joined in an impressive program featuring John V. Kennedy, radio commentator and former editor of Colliers.

From a 10,000 mi. air trip, during which he visited Diesel factories in all parts of the country and tried all forms of Diesel transportation from the giant Hindenburg to small fishing boats, Mr. Kennedy analyzed the Diesel from the layman's standpoint and weaved about the industry a spell of romance somehow missed by those responsible for the development of the industry.

The first presentation of Mr. Kennedy's address was arranged for by the National Exposition of Power and Mechanical Engineering. The second presentation at the Palmer House in Chicago on December 7th was arranged for largely by Mr. B. C. Heacock, president of the Caterpillar Tractor Co., with the assistance of the midwest Diesel manufacturers, including Col. Robert M. Morse of Fairbanks, Morse & Co., C. L. Cummins of Cummins Engine Co., and the Winton Engine Co.

It is expected that the program will be repeated later in San Francisco.

Supporting Mr. Kennedy, whose address was broadcast by WGN of Chicago, were many industrial, financial and political leaders of the middle west, a tribute perhaps not as much to Dr. Diesel and his work as to the popularity of Mr. Heacock, recently elected president of the Illinois Manufacturers Association.

Dr. Diesel, after an association with Dr. Linde and Sulzer Bros., obtained, in 1892, a patent on the engine which now bears his name. It was in December, 1897, however, that a commercial engine, a single cylinder, 25-hp. unit, was produced. Laboring under financial handicap, Dr. Diesel

Dr. Rudolf Diesel, inventor of the Diesel engine, born in France 1858 of Bavarian parents

was slow in promoting the wide adoption of the Diesel and disappeared under mysterious circumstances aboard a channel steamer just prior to the World War.

In 1896, Adolph Busch of St. Louis purchased the American rights on the engine and after some difficulty the first commercial engine was put into actual service in 1898. It was a 2 cylinder, 60-hp. unit. Following this the Diesel grew slowly but steadily in importance, particularly after the War. Each year has seen a steadily increasing output until in 1936 over 2,000,000 hp. was produced. As an example of how the industry has expanded of recent years, Mr. Heacock stated that the first Caterpillar engine was produced in 1931 and engine No. 21,000 was displayed at the New York Power Show. The total output has been over 1,125,000 hp., this year's total exceeding the combined total of previous years.

J. V. Munro, vice president Caterpillar Tractor Co., was chairman of the Chicago luncheon, introducing speakers representing many phases of the Diesel industry, for brief talks. Included were Charles E. Snyder, editor-in-chief of Corn Belt Farm Dailies; O. Fred Rost, editor-at-large of Business Week; Samuel Dunn, chairman of the board, Simmons-Boardman Publishing Co.; Col. Robert H. Morse, president, Fairbanks, Morse & Co.; Charles Deere Wiman, president of Deere & Co.; Edward Eagle Brown, president, First National Bank of Chicago; Mr. Cummins; Dr. George Michell, Peoria financier; Clarence Randall, vice president, Inland Steel Corporation.

Sturgis Turns to Diesel Standby

IN THE DESCRIPTION of the Sturgis Diesel plant appearing on page 696 of the December issue, it was stated that the two Busch-Sulzer engines are equipped with Bosch fuel pumps. This should be corrected in the original article as they advise us that not only these two engines, but, all Busch-Sulzer Diesels employing mechanical injection are fitted with fuel pumps and valves manufactured by the Busch-Sulzer Bros.-Diesel Engine Co. and employ the well-known Hesselman principle of mechanical injection.

Control of Refrigerants

D. D. Wile*

MUCH PROGRESS has been made during recent years in the control of refrigerant flow to surface coolers. This is especially true of systems employing the low pressure refrigerants such as Freon, Methyl Chloride and Sulphur Dioxide. This progress has been a result of improvement in the thermostatic expansion valves which are universally used to regulate the flow of refrigerant in these systems, and the development of suitable distributing headers in the case of large evaporators employing many tubes connected in multiple and supplied from one expansion valve.

A conventional thermostatic expansion valve consists in effect of two parts, the body proper and the thermostatic power element which consists of a bellows connected by means of a capillary tube to a feeler bulb. In operation the feeler bulb is clamped to the suction line leaving the evaporator and tends to modulate the opening of the needle so as to admit just the proper amount of refrigerant to keep the coil entirely refrigerated. Operation is shown in Fig. 1 where it will be noted that a substantially constant superheat of the gas leaving the evaporator is maintained even though the suction pressure was varied through a very wide range.

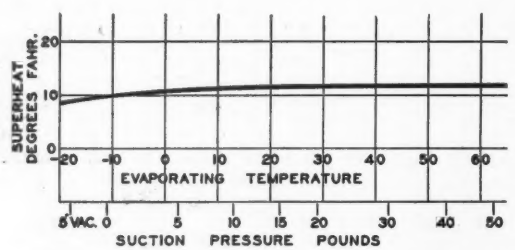


Fig. 1. Constant control of superheat over a wide suction range by a thermostatic expansion valve

It has been found by practical experience that the large majority of evaporators, either for low temperature work or air conditioning service, operate satisfactorily at approximately 10 deg. superheat. When a valve is adjusted for 10 deg. superheat it is seldom necessary to change this adjustment regardless of whether the valve is applied to high temperature or low temperature applications. This condition has made it possible to adjust the valves at the factory and thus eliminate much inconvenience in the field. In fact, a non-adjustable type of expansion valve, which operates on the same principle has been developed, and has wide use in air conditioning, commercial, and low temperature applications.

*Chief Engineer, Refrigeration & Air Conditioning, Detroit Lubricator Co. This is an abstract of a paper presented before the International Congress of Refrigeration at The Hague.

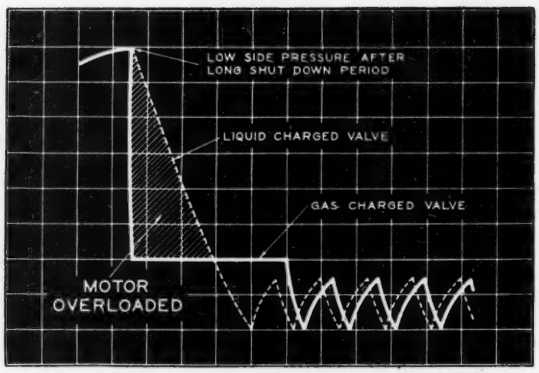


Fig. 2. Difference in characteristics between a liquid filled and gas filled valve

A very recent improvement in thermostatic expansion valves has been the adoption of a gas charge in the thermostatic power element in place of the liquid charge. The characteristic pull-down operation of a system employing the gas charged valve and the usual liquid charged valve is shown in Fig. 2. It will be noted that the gas charged valve allows the system to quickly pull down to a moderate pressure, thus protecting the motor against overload. After the initial pull-down period it will be noted that the operation of the gas charged valve is exactly the same as the liquid charged valve.

Figure 3 shows the cross section of a large capacity thermostatic expansion valve employing the same principles of operation as the valve first mentioned. This valve has been developed for various capacities up to 20 t. freon and 35 t. methyl chloride. It is designed to maintain a constant degree of superheat in the suction gas as shown in Fig. 1 and is adjusted at the factory to maintain maximum coil efficiency. Although an adjustment is provided as shown at Q it is seldom necessary to change the factory setting. The valve is also gas charged so as to protect the motor against overload when starting up a warm system or when operating conditions become abnormally heavy.

In large capacity coils there is oftentimes a large drop in pressure between the inlet and the outlet and this may interfere with the accuracy of the expansion valve operation due to the higher pressure existing at

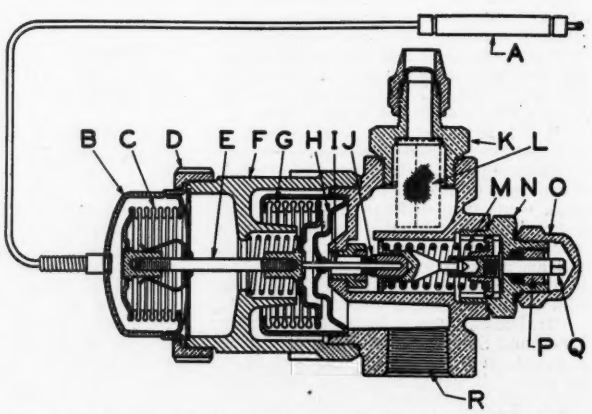


Fig. 3. A gas charged thermostatic valve built in sizes up to 20 t. for Freon and 35 t. for Methyl Chloride

the inlet tending to cause the valve to close and starve the coil. If the pressure difference between the inlet and outlet of the coil exceeds 4 lb., it may not be possible to adjust the valve to properly compensate and the result will be inefficient coil operation. In order to overcome this condition the valve shown in Fig. 3 is provided with an equalizer connection which connects between the valve body and the suction line so as to permit the valve to operate from the pressure at the suction end of the coil rather than the pressure at the inlet. This equalizer connection is particularly important when using a distributing header such as shown by Fig. 4, which may in itself produce a considerable pressure drop.

The modern type of finned coil is generally constructed with a comparatively small size tube, in most cases this being about ⅝ or ¾ in. O. D. This size tube is limited in the amount of refrigeration capacity that it will handle due to the building up of excessive pressure drop on large capacities. Therefore, on large size coils it becomes necessary to operate tubes in multiple and this presents a very serious problem in the distribution of refrigerant to the various tubes.

Several years ago it was not at all uncommon to find a large evaporator connected up as shown in Fig. 5A, with the result that it was difficult or impossible to obtain high efficiency from the coil. Note that the arrangement of the coil places the various passes in such a position that they receive unequal loads. The pass next to the incoming warm air has a much higher rate of heat transfer than the pass on the other side of the coil in the path of the cooled air. Since the pressure drop between the inlet and outlet header must be equal in the various passes it is obvious that a portion of the coil will be starved.

The use of orifices at the inlet header to proportion the amount of refrigerant entering each of the tubes has been tried, but generally involves difficulty because the distribution does not remain constant under various conditions of load. The coil shown in Fig. 5A would be greatly improved if the passes were rearranged so that each had an equal load, but there would still be the problem of distributing the refrigerant equally to each tube.

The method of connecting up the distributing header to the coil is shown in Fig. 5B. Note that each pass through the coil is arranged so as to have equal loading, and, therefore, each tube requires the same amount of refrigerant. This sketch also shows the method of connecting the equalizer tube of the expansion valve into the suction line so that the valve responds to the pressure at the exit of the coil and permits the coil to work at maximum efficiency regardless of the amount of pressure drop through the coil.

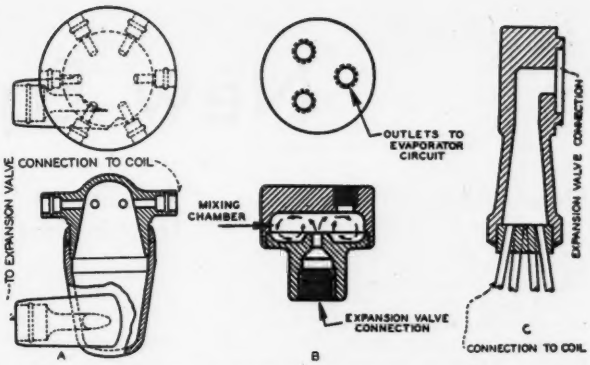


Fig. 4. Three types of distributing headers, A, Carrier, B, York, C, Westinghouse

A somewhat different method of obtaining distribution through the coil is employed by Bruce Palmer, Inc., Detroit, Mich., and is shown in Fig. 5C. Due to the fact that 80 per cent or more of the refrigerant entering the coil is in the liquid form, there is a much slower velocity entering the coil than there is at the exit when all of the liquid has been vaporized into gas. The arrangement shown in Fig. 5C takes this fact into consideration by causing the refrigerant leaving the expansion valve to pass through a single tube for a portion of the coil surface until its velocity has been increased sufficiently to prevent separation of liquid and vapor. The tube is then teed into two tubes which likewise pass through sufficient surface to again build the velocity up where it can be further split up. We are advised that successful designs of the type of coil shown in Fig. 5C have employed refrigerant velocities of between 1000 and 2000 ft. per min. before entering the tee and splitting into two feeds.

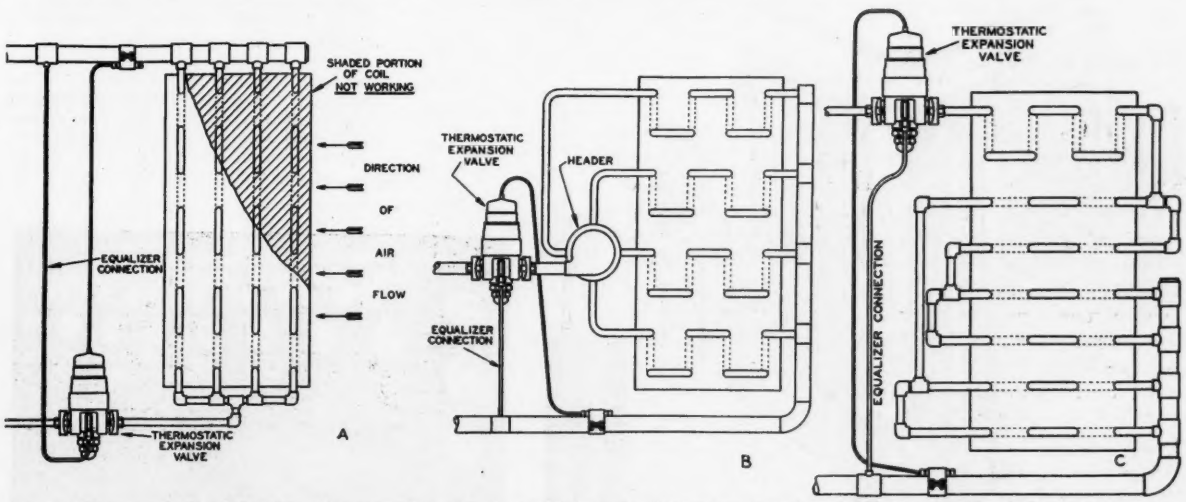


Fig. 5. Three methods of feeding refrigerants to coils. A, results in poor distribution; B, with a distributing header of the type shown by Fig. 4, gives even distribution to all coils; C is the method used by Bruce Palmer, Inc.

New Equipment

New Anderson Trap

Two New Traps are announced by the V. D. Anderson Co., 1935 W. 96th St., Cleveland, Ohio. The first is the Super-Silvertop combination thermostatic and inverted bucket trap making possible complete air elimination at extremely low pressures such as often occur on systems where fires are banked at night yet steam circulation is desired. These traps are available in pipe connections up to 1¼-in., with capacities up to 10,200 lb. They may be used on systems with pressures of from a fraction of an ounce to 50 lb.

The second trap is Super-Silvertop No. 10 designed and priced so that the smaller steam using unit may be individually trapped. This trap is only 4 in. high but has practically all the larger Super-Silvertop trap features. It is suitable for use on coffee urns, steam tables, unit heaters, sterilizing equipment, compressors, laundry machinery, radiators, etc., and is made with ½ in. pipe connections for a maximum gage pressure of 125 lb. per sq. in.

Supported Furnace Walls

The design of supported furnace wall, illustrated, was developed by George P. Reintjes Co., Kansas City, Mo., with the following principles in mind: The wall is sectionalized, each section being built totally independent of any other section. The weight of all the refractories is transferred to a supporting steel frame work. The wall is designed in such manner that all of the supporting metal is entirely in the back of the refractory, where it can be cooled by circulating air. The joints are broken so as to prevent infiltration of air into the furnace. The spacing of the refractory belts can be varied simply by increasing or decreasing the number of courses of standard fire brick. This flexibility reduces the number of casting and tile shapes required.

Anti-Freeze System for Air Lines

Tanner Tank air line anti-freeze system, built by Sullivan Machinery Co., to eliminate air line and air tool freezing,

has recently been improved as shown in the accompanying illustration, to give greater convenience in connections and more certain feeding. It is harmless to metal, hose or lubrication, with tanks built to A.S.M.E. specifications of welded construction for 200 lb. working pressure and easily installed.

Remote-Reading Gage

Convenient and exact reading of boiler water gages is made possible through the Eye-Hye, the new remote-reading gage of the Reliance Gauge Column Co., Cleveland, Ohio.

This Eye-Hye, developed by Reliance engineers, brings the reading down to a clear, convenient eye-height, showing the precise level of the water in the boiler as a bright, green liquid, sharply illuminated. In addition to its accuracy, it brings the reading down around girders, corners, piping, anywhere within reasonable distance.

Water Coolers

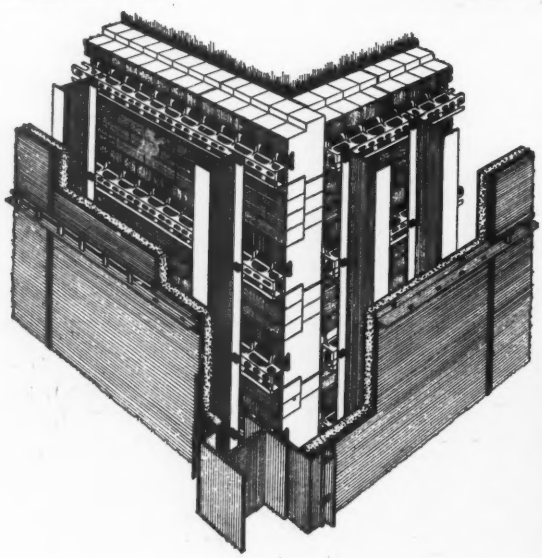
Especially Designed to operate in temperatures below freezing, three new Freeze-Proof Water Coolers, models FWPF-8, FWPF-65, and FWPF-14 are announced by Westinghouse Elec. & Mfg. Co., Mansfield, O. These new Freeze-Proof Coolers are particularly suitable for general industrial use such as in steel mills, factories, and other places where they may be subjected to sub-freezing temperatures.

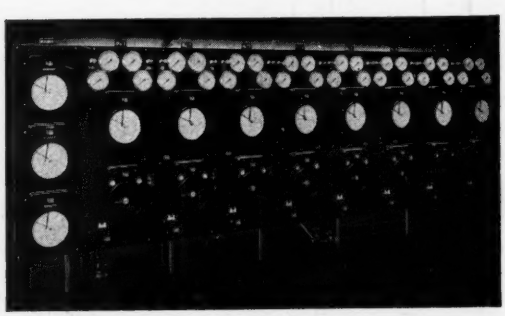
The coolers are especially insulated and equipped with thermostatically controlled Corox heating elements, mounted in the lower part of the cabinet. With this arrangement, these coolers will operate without freezing in temperatures as low as 20° F. below zero. The model FWPF-65 cooler has a capacity to cool 9.5 gal. of water per hr., from 70 to 50 deg. F.; the FWPF-8 cooler delivers 11.9 gal.; and the FWPF-14 cooler, 14.4 gal. per hr. under similar conditions.

Process Control System

A new system, known as the Coördinated Control System, for automatically operating all of the technical operations and factors of an industrial process has been announced by The Bristol Co., Waterbury, Conn. This system makes it possible to put intricate scientific processes under complete automatic control, thus eliminating the necessity of leaving the manipulation and control of critical operations in the hands of plant operatives.

The control system is for processes that are developed and perfected in the laboratory and pilot plant, and depend on rigid control of such factors as the time of operations of valves (all sizes up to large gate valves), pumps, blowers, dampers, etc. and the control at a definite value





or according to a time program of such variables as temperature, pressure, liquid level, flow, humidity, and speed for their success. It has been found in a number of cases that the Coordinated Control System was the tie-over from the experimental stage to the full-scale plant stage that made for success.

The Coordinated Control System can be applied to any process of which the exact schedule of operation for best overall results is known. It is an automatic machine built in the form of a master control station. It consists of recording and controlling instruments built around the so-called "Mechanical Brain". Each system is designed and engineered for the particular process on which it is used.

The "Mechanical Brain" coördinates the efforts of instruments and automatically regulates all of the operations in the process. It is in a way the "pace maker" or "monitor" in that it regulates all of the operations, making them take place in their proper sequence and run for a scheduled time.

Dr. Charles Legeyt Fortescue Dies

Dr. Charles LeGeyt Fortescue, consulting transmission engineer of the Westinghouse Electric and Mfg. Co., died in his home in Pittsburgh, Friday evening, December 4, after a lengthy illness.

Dr. Fortescue was internationally famous for his work in curbing the effects of lightning on transmission lines and distributing systems.

Perhaps the greatest of his contributions was the development of a branch of mathematics known as symmetrical coordinates. As this lies in the field of pure

mathematics it was of great value to educational institutions as well as to practical industry.

Nearly 200 patents were credited to him covering a wide range of research, product development and protective devices. Pioneer work on alternating current railway networks is in his record as is also the design for the first 100,000 v. transformer for commercial service. Much of the development on the theory of transformer design was performed by him, either actively or in a consultive capacity.

Born in York Factory, Canada, November 7, 1876, he received his earlier education in Dawlish, South Devon, England. In 1898 he received his Bachelor of Science Degree from the Queen's University at Kington, Ont., and then joined the Westinghouse Electric and Mfg. Co.

In 1926 he was made consulting engineer on transmission which position he occupied until his death. In addition to his engineering work he prepared and read many engineering papers before electrical institutes.

In 1929 Queen's University, conferred upon him a doctor's degree and in 1931 he received the gold medal of the Franklin Institute for his work in the development of the theory of symmetrical coördinates. He was a fellow of the American Institute of Electrical Engineers.

Talbot Awarded John Fritz Medal

Arthur Newell Talbot, professor emeritus of engineering in the University of Illinois, has been awarded the 1937 John Fritz Gold Medal, highest of American engineering honors. Prof. Talbot, who is 79, was cited as "moulder of men, eminent consultant on engineering projects, leader of research, and outstanding educator in civil engineering."

The award is made annually for notable scientific or industrial achievement by a board composed of sixteen past-presidents of the four national societies of Civil, Mining and Metallurgical, Mechanical, and Electrical Engineers.

Prof. Talbot was born in Cortland, Ill., October 21, 1857. He received the degree of bachelor of science from the University of Illinois in 1881, and the degree of civil engineer in 1885. Honorary degrees were conferred on him by the University of Pennsylvania in 1915, the University of Michigan in 1916, and the University of Illinois in 1931. He has been engaged in engineering work since 1881, his activities embracing railroads, roads, bridges, buildings, and municipal public works.

News from the Field

Refrigerating Machinery Association at its recent meeting in Washington, elected the following officers: President, J. M. Fernald, Baker Ice Machine Co., Omaha, Neb.; Vice-President, A. H. Baer, Carbondale Machine Corp., Harrison, N. J.; Executive Committee, D. Norris Benedict, Frick Co., Inc., Waynesboro, Pa., G. A. Heuser, Henry Vogt Machine Co., Louisville, Ky., J. I. Lyle, Carrier Corp., Newark, N. J., W. S. Shipley, York Ice Machinery Corp., York, Pa., Emil Vilter, Vilter Mfg. Co., Milwaukee, Wisc.

Elgin Softener Corp., Elgin, Ill., announces appointment of Harold M. Wall as representative for southeastern and western Texas and for central and northern Louisiana, with offices at 1713 Missouri Ave., Houston, Tex.

Link Belt Co., Chicago, has appointed P. B. Engstrom, formerly with Garfield & Co., as distributor for crawler shovels, draglines and cranes for southern California with office at 361-9 So. Anderson St., Los Angeles. B. Howard MacNeal has been transferred from Memphis to specialize on cranes for industrial use in Philadelphia and New York territories from the company's office at 2045 W. Hunting Park Ave., Philadelphia. E. F. Carey in Philadelphia and Chester S. Lewis in New York will continue as district representatives for cranes for all other uses.

The Smoke Prevention Association, through its secretary-treasurer, Frank A. Chambers, Smoke Inspector of Chicago, has announced that the 31st annual convention will be held on June 2, 3, and 4, 1937, in the Hotel Pennsylvania, New York City. In conjunction with the convention, the Association is sponsoring an exhibition dealing with fuel burning equipment and air pollution which will also be held in the Hotel Pennsylvania, opening on Monday ,June 1 and continuing daily through June 6. On the second day of the convention, June 3, all sessions will be held at Stevens Insitute, Hoboken, N. J., and that day will be set aside as Hudson County day in recognition of the activities of the Hudson County Smoke Association.

The purpose of this year's program will be: (1) To make possible a visualization of Air Pollution Problems, its Prevention and Control; (2) To provide a personal program for the average New York citizen other than technical papers presented during the regular convention hours; (3) To crystallize and instill in the minds of local citizens the following: (a) Purpose and necessity of Smoke Department, and Air Pollution Surveys; (b) Public support for Smoke Ordinance enforcement; (c) The ultimate goal of Air Pollution prevention, control, conservation of assets, protection of public health, etc.

The functions of the exhibit program will be: (1) To provide an exhibition of individual exhibits, depicting proper fuel-firing, care and operation of equipment, dust fall, noxious gas emissions, results of prevention and control in other cities; (2) Special lectures with motion pictures will be given daily for special New York groups as follows: Domestic Groups—(Home Owners—Apartment Owners, Real Estate men)—Power Industrial Group—(Utility Officials, Industrial men)—Railroad men—(All rail officials and employees) — Equipment manufacturers, building architects, coal dealers, coal merchants and wholesalers, oil dealers, gas and electric distributors, city officials, engineers, doctors, legal talent and newspapermen.

As this will be the first fuel burning—air pollution exhibit ever held in New York City and the first time the general public has had an opportunity to get first hand information on these two most important and timely subjects, a record attendance is expected. Exhibitors will be given blocks of invitations to distribute, for no admission fee will be charged. At an estimated expense of $75,000 the Hotel Pennsylvania has let contracts for air conditioning the rooms to be occupied for the convention sessions and exhibits.

Frederick W. Doolittle, Vice-President of The North American Company and an officer and director of a number of its subsidiary and affiliated companies, has announced his retirement from executive work on December 1. Mr. Doolittle will continue as a Director of The North American Company.

Following officers were recently appointed by the Board of Directors of the General Refractories Co., Philadelphia: Lionel V. Greene, vice-president in charge of operations; Russell P. Heuer, vice-president in charge of research; Drew M. Thorpe, vice-president in charge of sales.

POWER FOR John Brown "University of the Air" and other industries, including building, agriculture, ice plants, factories and machine shops, located at Siloam Springs, Ark., will be supplied by a 250-hp. Cooper-Bessemer gas engine driving a 175-kv. a.c. generator. Radio broadcasting of station KUOA is expected to be raised to 50,000 w. for transmitting educational programs, no commercial or advertising programs to be carried. The new unit will furnish all power, including lighting and water supply, and some power may be sold to surrounding farms.

LEE B. METTLER, for many years closely identified with the gas industry, died in California on November 13 of a severe heart attack. Mr. Mettler was born in Adrian, Mich., in 1874. For the past fifteen years he was in business for himself as head of Lee B. Mettler Co., combustion engineers and manufacturers of gas burners, Los Angeles, Cal. The business will continue under the same name.

JOHN T. MURPHY has been appointed by the Frick Co. as branch manager of the New York office, located at 370 Lexington Ave.

YORK ICE MACHINERY CORP. of York, Pa., is reported by J. L. Rosenmiller, manager of Accessories, Equipment and Supplies Division, to have produced more than 2,000,000 gal. of special oils for refrigerating systems, in its blending plant; in one grade for Freon compressors, and in three grades for ammonia compressors; for operation below –20 deg. F., for –20 deg. to 320 deg., and for operation where discharge is above 320 deg.

VALVES FOR AIR-OPERATED CONTROLLERS, a 28-page illustrated bulletin just published by The Foxboro Company, Foxboro, Mass., provides a comprehensive review of control valves, both the throttling and quick-acting open and shut type with modern controller accessories for the practical application of automatic control.

PROTECTION of exposed steel structures by a new process known as "Synhibit" has been developed by Thompson & Co., Pittsburgh, Pa. The process involves wire brushing of the steel to remove loose rust, chemical pre-treatment by an inhibitor which kills the rust remaining on the surface or in the cracks and prepares the entire surface for the priming and finish coats. The metal is then protected against corrosion as long as the protective film endures.

AT A MEETING of the Board of Directors of The Timken Roller Bearing Company on December 5, action was taken on the following changes in officers and directors.

Resignations were accepted from Frederick J. Griffiths as Director of The Timken Roller Bearing Company and President and Director of The Timken Steel & Tube Company; and from K. B. Bowman as General Superintendent of the steel and tube mills of The Timken Roller Bearing Company.

William E. Umstattd was elected President of The Timken Steel & Tube Company which is a wholly-owned subsidiary of The Timken Roller Bearing Company, in addition to continuing his present capacity as President of the parent company.

H. H. Timken, Jr., previously a Vice-President of The Timken Steel & Tube Company, was made Executive Vice-President of The Timken Steel & Tube Company, in addition to his present capacity as Vice-President and Director of The Timken Roller Bearing Company.

W. Robert Timken was elected Director of The Timken Roller Bearing Company and of The Timken Steel & Tube Company to fill the vacancy of the unexpired term.

John E. Fick was appointed General Superintendent of the steel and tube mills.

UNION IRON WORKS, Erie, Pa., have appointed The M. G. Limbach Co., 5005 Euclid Ave., Cleveland, Ohio, as their representative in Cleveland and the surrounding Ohio territory.

J. N. PILCHER and Dr. C. A. Barnes have been appointed research engineers in the Fuels Division at Battelle Memorial Institute, Columbus, Ohio.

PAUL H. SMITH, for the past 10 yr. Manager of the Detroit District of Combustion Engineering Company, Inc., died at Detroit on November 23rd following a lingering illness. Mr. Smith, after graduation in electrical engineering from Lehigh University in 1902, entered the employ of the Westinghouse Electric & Manufacturing Company, leaving in 1909 to become Superintendent of the Pittsburgh & Butler Street Railway. After 2 yr. he returned to the Westinghouse Company with which he remained, in the capacities of service engineer, sales engineer and district engineer, until 1922. He then spent 2 yr. with the Brooklyn Edison Company and joined the Combustion Engineering organization in 1926.

BRISTOL'S INSTRUMENT Co., Ltd., London, England, celebrated its fourth year of manufacturing Bristol Instruments in England by moving into a new home located at Brent Crescent, North Circular Road, West Twyford. This was recently purchased to allow for an expansion program made necessary by an increased demand for the company's products and by the growing scope of the company's service facilities. The new building is of modern construction and will facilitate the manufacture of Bristol's Recording, Controlling and Indicating Instruments under the very best working conditions.

The move to larger quarters has been carried out under the direction of Mr. G. H. Gaites, Managing Director. It forms part of a program of expansion which is being followed by the associated companies, The Bristol Company of Canada, Ltd., 64 Princess Street, Toronto, Ont., Canada, and The Bristol Company, Waterbury, Connecticut, U. S. A. This broad policy of expansion has been encouraged through the increased adoption of control instruments by industrial plants not only as a means of standardizing the product quality, but also for purposes of reducing operating costs.

THREE electric heating units, two of 168 kw. and one of 135 kw. capacity have been purchased for an air conditioning system in the quarters at Bonneville Dam, to heat 20,000 cu. ft. per min. of air. The units are in series, the first to preheat air before washing, the second to reheat after washing, and the smaller unit as a final booster. Units will be supplied by Electric Air Heater Co., Mishawaka, Ind., with finned grids in sections, each section being removable independently for cleaning or repair.

J. E. TOBEY, manager of fuel engineering division, Appalachian Coals, Inc., has been elected chairman of the Ohio Valley Section of Amer. Inst. of Min. and Metall. Engrs., which covers Ohio and parts of Indiana, Kentucky and West Virginia. Byron Bird, chief concentration engineer of Batelle Memorial Inst., was elected secretary and he and Mr. Tobey are now busily planning for the conference to be held at Cincinnati in October, 1937.

THE INTERNATIONAL NICKEL Co., Inc., has announced the addition of Gerald R. Brophy to the development and research staff. Mr. Brophy will be located at the research laboratory of the company in Bayonne, New Jersey. His time will be devoted largely to research problems relating to nickel alloy steels, nickel cast irons and other ferrous materials.

ARRANGEMENTS have been made by the American Foundrymen's Association for an interesting symposium on January 14th at which representatives of the producers of the various alloying elements will discuss the improved mechanical properties obtainable by the use of alloys in cast iron. Speaking for nickel, Fred J. Walls will discuss the advantages of the nickel alloyed cast irons and describe some applications in the industries in which their greater strength and hardness, improved rigidity, pressure tightness and uniformity of grain structure coupled with ready machinability and good castability is essential. Mr. Walls is a member of the Development and Research Division, The International Nickel Co. The meeting will be held at the Cleveland Club, Carnegie Avenue and East 107th Street in Cleveland.

C. T. PARKER has been appointed to represent the Elgin Softener Corp., Elgin, Ill., in New York State. Mr. Parker has been active in the power plant field in this territory for a number of years. His offices will be located at 184 Broadway, Rochester, New York.

THE INSTALLATION of the widest solid-woven belting loom in the world, a 20 T. loom that will weave cotton belting in widths up to and including 84 in., has been completed by Victor Balata & Textile Belting Co. at their Easton, Pa., plant.

This new and unusual loom will supplement other equipment for the manufacture of a complete line of belts for driving, conveying, and elevating, including another large loom installed in 1935, a loom producing belting having a maximum width of 63 inches.

For the Engineer's Library

FLOW METER ENGINEERING HANDBOOK. By Louis Gess and J. O. Feldmark. Published by Brown Instrument Co., Philadelphia, Pa. Size 8 by 10½ in., 144 pages. Price $2.

Written from the standpoint of supplying power plant engineers with data on the measuring of steam, air, oil and other fluids, this book is divided into eight parts, discussing general flow meter engineering, orifice design, steam flow measurement, water flow measurement, liquid flow measurement, gas flow measurement, general tables and data. Various factors used in calculating the flow of various liquids are contained in their respective sections. Section one on general engineering gives the general principles of operation and construction of Brown electrical and mechanical meters, indicators, recorders and integrators.

THERMODYNAMIC PROPERTIES OF STEAM, by J. H. Keenan and Frederick G. Keyes. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York. Size 7½ by 10 in., 89 pages. Price $2.75.

Commonly known as steam tables, the present volume represents the results of several years' research work here and abroad to fill in large gaps in previous experimental work and extend the range and accuracy of the tables.

In addition to a number of new tables covering compressed liquid, viscosity, heat conductivity and thermometer calculation formulas, there are a number of charts of specific heat not heretofore available. They show the extraordinarily rapid changes and large values of the quantity corresponding to volumes at and near the critical state. A large scale Mollier Diagram covering a temperature range up to 1000 deg. is included in the jacket in the back of the book.

STATISTICAL ANALYSIS OF INDUSTRIAL PROPERTY RETIREMENTS by Robley Winfrey. Published as Bulletin 125 of the Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa. This is a 176 page, paper bound volume, giving a complete discussion of the determination of depreciation expense and probable service lives of property, based upon retirement data supplied by industrial and utility companies.

THE BROWN INSTRUMENT CO. has just published a new broadside entitled: "Here's the Answer to Your Temperature Problem," featuring Brown Thermometer Controllers. This new broadside graphically describes the accuracy, simplicity and ruggedness of Brown Thermometer Controllers. It illustrates the ease with which Brown Air-o-Line Thermometer Controllers may be "tuned" to specific process requirements and in addition gives in detail the other features and the ranges of both air operated and electric types of controllers.

D. W. HAERING & CO., INC., 3408 W. Monroe St., Chicago, Ill., has published for distribution to interested engineers a new 16-page booklet entitled, "Organic Methods of Scale and Corrosion Control." This booklet presents scientific information regarding the application of organic chemicals to water conditioning problems. It defines the various chemical theories employed in this field in simple detail and includes a history of the subject along with an explanation of the control methods employed at the present. The chemical formulae and properties of such new organic chemicals as beta glucoside, sodium glucosate, pyro glucosate, chrom glucosate, phospho glucosate and sulpho glucosate are listed and described.

IN A NEW BULLETIN, designated as Form 499, Griscom-Russell Co., 285 Madison Ave., New York, N. Y., has described the design of heating elements employed in an exceptionally compact and effective storage tank oil heater. The bulletin also illustrates alternate methods of this heating element's application at storage and service tanks, loading wharves and platforms, chemical and gas plants.

HOW MUCH IS SLUGGISH HEATING COSTING YOU? This is the title of a folder just issued by Hoffman Specialty Co., Inc., Waterbury, Conn., describing Hoffman-Economy vacuum pumps.

NEW Watson-Spicer flexible drive with needle roller bearings is shown in a catalog just issued by H. S. Watson Co., San Francisco, Calif.

MONARCH MFG. WORKS, INC., Salmon and Westmoreland Sts., Philadelphia, has recently issued several sections of its Catalog 6 dealing with spray nozzles and oil burner accessories manufactured by the company.

A NEW CATALOG describing the Coe Drainator, which is a device for the removal of condensate and air from piping and steam heating systems, has just been issued by the Coe Mfg. Co., Painesville, Ohio. In the catalog the device is illustrated and the principles of operation described together with numerous charts to show capacities and other characteristics of operation.

REEVES PULLEY CO., Columbus, Ind., has recently published a booklet on the subject of variable speed control under the title Speed Control at Work. This booklet is a brief inspection, both by word and illustration, of the methods employed by 12 nationally known manufacturers in securing complete speed adjustment of production machines in their plants.

A NEW PUBLICATION entitled Types SH and DH Speed Reducers has recently been issued by the Westinghouse Electric and Manufacturing Company. Describing single and double reduction units of the single helical gear type with anti-friction bearings and splash lubrication for application in general industrial and mining operations, the booklet describes the construction, design, efficiency and ratings of these gear units. Also included are available speed ratios, methods for selecting the proper reducer and horsepower ratings in accordance with the American Gear Manufacturers Association.

SCHRAMM, INC., West Chester, Pa., has recently issued a bulletin giving detailed specifications and dimensions on the complete line of Schramm assemblies of air compressors. These stationary compressors are complete, self-contained units with automatic control water cooling system, air tanks, motors, assembled as one unit on one frame, ready for installation.

LINCOLN Shield Arc SAE welder with dual continuous control is described in bulletin No. 315 issued by The Lincoln Electric Co., Cleveland, Ohio.

ILLINOIS Central R. R. has purchased a 2000 hp. Diesel-electric locomotive, which is described and illustrated in a pamphlet sent out by Busch-Sulzer Bros.-Diesel Engine Co., St. Louis, Mo.

DIVERSIFIED uses of wrought iron are covered in the December bulletin of Reading Iron Co., Philadelphia, Pa., which touches on iron gates for Virginia, piping for Idaho hotels, and for oil tankers, uses of cut nails which are still in demand, plough shares, lamps and saddle stirrups.

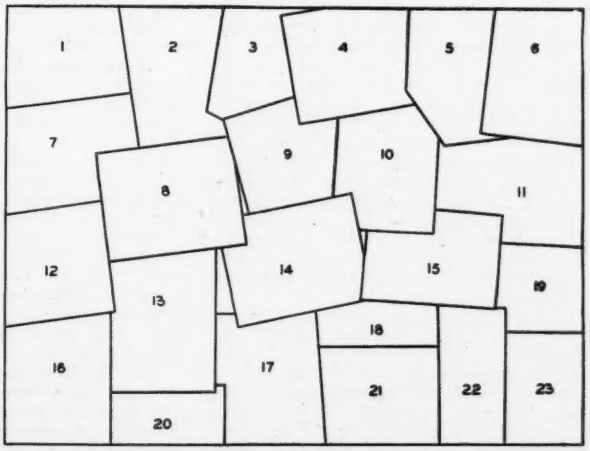
INTERESTING EXAMPLES of the uses of Toncan metal for bridges, air ducts, steam pipe and cooling towers are shown in Toncan Topics issued by the Republic Steel Corpn., Cleveland, Ohio.

FROM Snap-On Tools, Inc., Kenosha, Wisc., comes Catalog L of its complete line of wrenches including socket sets, open and closed, straight and S wrenches, adjustable types and numerous special tools for industrial and automobile work. Also Catalog 36-BA covering reamers cleaning and buffing tools, electric drills, grinders, and special heavy-duty wrenches.

BULLETIN No. 308, describing type GN Diesels, has just been released by the Cooper-Bessemer Corp., Mt. Vernon, O. This new engine is built in 3, 4, 6, and 8 cylinders, rated at from 50 to 58 hp. per cylinder.

POWER COMES OF AGE

THOSE wishing to identify the individual pictures shown in the group photograph on pages 2 and 3 may do so by means of the accompanying diagram.



1. Two 7000 hp. steel mill motors on test at the Westinghouse works. 2. View of a large stearic acid condenser in industrial plant using aluminum piping. 3. 287,000 v. switching equipment on the Boulder Dam transmission line. 4. Water cooled underfeed stoker at the American Engineering Co. shops. 5. Plaque erected in honor of the late Dr. Elwood Mead at Boulder Dam. 6. Pulverized coal burners at the new "top" plant of the Rochester Gas and Electric Co. 7. Operators at work on a large short circuit calculating board used for calculating network performance. 8. View at Grand Coulee Dam, showing the first million cubic yards of concrete in place. 9. Large Diesel engine on test in the Busch-Sulzer shops. 10. Unusual view of the interior of a paint pigment dryer using aluminum tubes. 11. Diesel engine generators at the new plant at Tipton, Indiana. 12. Boiler control panel at the Lakeside station in Springfield, Ill. 13. At the World Power Conference held in Washington in September. Secretary of State Cordell Hull, Dr. W. F. Durand and Dr. Julius Dorpmuller of Germany. 14. The opening of Boulder Dam, initiated by President Roosevelt from Washington, D. C. 15. At work on the Bonneville Dam on the Columbia River. 16. President Roosevelt pressing the key which formally opened Boulder Dam, during the World Power Conference. 17. Assembling the 287,000 v. disconnects at Boulder Dam. 18. The turbine room at the new top plant of the Rochester Gas and Electric Co. 19. The Diesel engine enters the automobile field. 20. Seals for the shaft of hydrogen cooled generator. 21. Mercury arc rectifiers supplying direct current to the Delaware River Bridge traction system shown in 22. 23. Visitors viewing a high voltage discharge in the laboratories of the Westinghouse Electric and Mfg. Co.

Power Plant Construction News

Ark., Hot Springs—Arkansas Power & Light Co., Pine Bluff, Ark., has approved plans for new hydroelectric generating plant on Ouachita River, vicinity of Hot Springs, with initial capacity of 31,700 hp. It is scheduled for completion late in 1937 and will cost over $4,000,000, including transmission lines. Company will also build an addition to steam-electric generating plant at Little Rock, Ark., with installation of new 10,000-kw. turbo-generator and accessory equipment. Latter project will cost about $500,000.

Calif., Los Angeles—Liquid Carbonic Pacific Corporation, Ltd., 2600 East Twelfth Street, plans installation of electric power equipment in new addition to carbonating machinery manufacturing works, 50x190 ft., for which superstructure will begin soon. Entire project will cost close to $80,000. Blaine Noice, 5436 Carlton Way, is engineer.

Conn., West Haven—Armstrong Rubber Co. plans installation of electric power equipment in new addition to automobile tire and tube-manufacturing plant, three-story, 80x180 ft. Cost close to $100,000. Fletcher-Thompson, Inc., 1336 Fairfield Avenue, Bridgeport, Conn., is architect and engineer.

Fla., Jacksonville—Department of Public Utilities, Ernest E. Anders, commissioner, has plans under way for extensions and improvements in municipal electric light and power plant, including installation of new steam turbo-generator unit and accessory equipment. Cost about $2,375,000, of which approximately $1,125,000 will be secured through Federal grant.

Fla., Tampa—Continental Can Co., 100 East Forty-second Street, New York, N. Y., plans installation of electric power equipment in new multi-unit plant at Tampa, where tract of 45 acres of land has been acquired. A power house will be built. Entire project will cost about $500,000.

Ga., Newnan—City Council will receive bids until Jan. 8 for equipment for municipal waterworks, including centrifugal pumping unit with capacity of 1500-gal. per min., and complete accessories, filter gauges, meters, etc. Wiedeman & Singleton, Candler Building, Atlanta, Ga., are consulting engineers.

Ill., Chicago—Product Terminal Corporation, Thirty-ninth and Morgan Streets, has filed plans for one-story addition to steam power plant, estimated to cost about $100,000, with equipment. Work will be placed under way soon. A. Epstein, 2001 West Pershing Road, is consulting engineer.

Ill., Moline—J. I. Case Co., Racine, Wis., manufacturer of agricultural machinery and parts, plans installation of electric power equipment in new branch plant at Moline, where company has acquired former factory of Velie Motors Corporation, and will remodel and improve. Entire project will cost over $150,000.

Ill., Morris—Illinois Clay Products Co. plans installation of power equipment in connection with proposed rebuilding of fire clay products plant, recently destroyed by fire. Loss estimated close to $50,000. Company headquarters are on Chicago Street, Joliet, Ill.

Iowa, Eldora—Common Council has authorized surveys and estimates of cost for new municipal electric light and power plant. Young & Stanley, Inc., Muscatine, Iowa, is consulting engineer.

La., Tallulah—Chicago Mill & Lumber Co. plans installation of power equipment in connection with proposed rebuilding of local veneer mill, recently destroyed by fire. Loss estimated over $600,000, including power house. Main offices of company are at 111 West Washington Street, Chicago, Ill.

Md., Baltimore—Standard Wholesale Phosphate Co., Mercantile Trust Building, plans installation of power equipment in new three-story addition to commercial fertilizer plant in Curtis Bay district, 112x450 ft. Cost about $100,000.

Mass., Boston—White Fuel Corporation, 900 East First Street, has plans under way for new coal elevator on waterfront at South Boston, to replace a structure recently destroyed by fire. Installation will include elevating, conveying and loading equipment. Cost about $50,000. George P. Carver Engineering Co., 114 State Street, is consulting engineer.

Mich., Jackson—Goodyear Tire & Rubber Co., Akron, Ohio, plans installation of electric power equipment in new automobile tire and tube manufacturing plant at Jackson, where company has acquired local factory of Kelsey-Hayes Wheel Co. Structures will be remodeled and improved at early date. Entire project will cost over $150,000.

Minn., Halsted—Village Council has authorized surveys and estimates of cost for proposed municipal electric light and power plant. Ealy G. Briggs, 1955 University Avenue, St. Paul, Minn., is consulting engineer.

Mo., Cabool—Common Council has plans under way for new municipal electric light and power plant. Proposed to begin work soon. Fund of $50,000 has been secured through Federal aid.

N. C., High Point—City Council has plans maturing and proposes to begin work early in 1937 on new municipal hydroelectric power plant on Yadkin River, vicinity of Winston-Salem, N. C., where site has been selected. A transmission line will be built to city limits, where large power substation will be located. Entire project will cost about $6,000,000, of which $2,595,000 will be secured by a Federal grant. E. M. Knox is city manager in charge.

N. C., Plymouth—Kieckhefer Container Co., West Canal Street, Milwaukee, Wis., plans installation of electric power equipment in new multi-unit pulp

N. D., Walhalla—City Council has plans maturing for new municipal electric light and power plant. Cost about $50,000. Financing has been arranged through Federal aid. C. D. Norton, Bismarck, N. D., is consulting engineer.

Ohio, Cleveland—Brewing Corporation of America, Inc., East Ninety-third Street and Quincy Avenue, S. E., plans installation of power equipment in new addition to brewery. Entire project will cost close to $100,000. Ernest McGeorge, 1900 Euclid Avenue, is architect and engineer.

Okla., Oklahoma City—E. A. Liebmann, 628 Culbertson Drive, has plans for new one-story ice-manufacturing plant, 50x75 ft., at 1106 North May Street. Cost about $40,000, with equipment. Work will be placed under way soon.

Ont., Toronto—Holdsworth Co., Ltd., 2070 Lavard Street, Montreal, Que., operating a textile dyeing and finishing plant, plans installation of electric power in new branch mill at 349 Carlaw Avenue, Toronto, where tract of land has just been acquired. A boiler plant will be built. Entire project will cost about $80,000. G. P. Holdsworth is general manager.

Texas, Brenham—City Council is having plans completed for proposed municipal electric power plant, with installation to include four 250-kw. Diesel engine-generator units and accessory equipment. Cost about $310,000, of which $140,000 will be secured through Federal aid.

Texas, Corpus Christi—Barnsdall Oil Corporation, Petroleum Building, Tulsa, Okla., plans installation of power equipment, pumping machinery, steel tanks and other equipment in proposed new oil refining plant at Corpus Christi, to be equipped to handle about 10,000 barrels of crude oil per day. A power house will be built. Entire project is reported to cost over $600,000.

Texas, Houston—Regan Forge & Engineering Co., San Pedro, Los Angeles, Calif., plans installation of electric power equipment in new branch oil-well tool manufacturing plant at Houston, where site is being secured. Entire project will cost about $100,000.

Va., Franklin—Chesapeake Corporation, West Point, Va., manufacturer of kraft board and paper products, plans installation of electric power equipment in proposed new multi-unit mill at Franklin, where property is being selected. A power house will be built. Entire project is reported to cost in excess of $1,500,000.

Va., Staunton—Oscar Nebel Co., Inc., Winchester, Va., and Hatboro, Pa., manufacturer of hosiery, plans installation of electric power equipment in new one-story knitting mill, 110x150 ft., at Staunton. An air-conditioning system will be installed. Entire project will cost over $175,000.

Wis., Janesville—Chevrolet Motor Co., 1200 Industrial Avenue, plans installation of electric power equipment in new one-story addition to local assembling works, 45x600 ft. Entire project will cost over $100,000. Company headquarters are at 3044 West Grand Boulevard, Detroit, Mich.

Wis., Waukesha—Hein-Werner Motor Parts Corporation, 1200 National Avenue, plans installation of electric power equipment in two new additions to plant. Entire project will cost over $60,000. Work is scheduled to begin at early date.